- **There is also a potential for pests to evolve resistance** to the toxins produced by GM crops and the risk of these toxins affecting non-target organisms. There is also the danger of unintentionally introducing allergens and other anti-nutrition factors in foods.

SWAMINATHAN CALLS GM CROPS A FAILURE

Leading agriculture scientist M.S. Swaminathan, in a research paper, has described Bt cotton as a 'failure'. The findings were published in paper 'Modern Technologies for Sustainable Food and Nutrition Security'. It is a review of crop development in India and transgenic crops – particularly Bt cotton, the stalled Bt brinjal as well as DMH-11, a transgenic mustard hybrid.

Key Observations

The paper notes that GE (genetically engineered) Bt cotton has failed in India. It has failed as a sustainable agriculture technology and has, therefore, also failed to provide livelihood security for cotton farmers who are mainly resource-poor, small and marginal farmers. Besides, the precautionary principle (PP) has been done away with and no science-based and rigorous biosafety protocols and evaluation of GM crops are in place. The paper also raises questions on the genetic engineering technology itself on the grounds that it raises the cost of sowing. Also, the insertion of foreign genes (in the plant) could lead to 'molecular and cellular events not precisely understood'.

Way ahead – Prof. Swaminathan's suggestions

The government should only use genetic engineering as a last resort. Genetic engineering technology is supplementary and must be need-based. Only in very rare circumstances (less than 1%) may there arise a need for the use of this technology.

23.13.3 Many Reasons Behind the Protest of Genetically Modified Plants in India

- Consumption of Bt-crop decreases immunity of human beings, so it is not safe for human health and it also affects surrounding diversity due to loss of some other important insect pollinators those also die due to consumption of Bt-crop.
- According to a research, it is observed that there are 33 side effects of Bt-Brinjal on human body and that is why it is now banned in India (earlier it was banned in USA, UK, Canada, Australia).
- People also protest Bt-Mustard in India due to its crossbreed with the native mustard crop and destroy natural variety.
- It has been observed that due to the Bt-crop seeds, there is stagnant yield, which leads to new pest attacks and disease these days.
- In the recent past, white fly has attacked Bt-cotton variety in Punjab and Haryana and has caused a rural crisis, so many farmers have committed suicide and protested to demand state aid.
- Approximately 50–60 per cent of the honey is produced in India through mustard crop. Its GM crop will harm honeybees.

23.13.3.1 Bt-Brinjal Ban in India

Bt-Brinjal plant has a resistance against lepidopteron insects like the Brinjal Fruit and Shoot Borer and Fruit Borer. The ingestion of the Bt toxin by the insect disrupted the digestive processes, which ultimately led to the death of the insect. In India, Bt-Brinjal is being developed by M/s Mahyco [Maharashtra Hybrid Seeds Company].

23.13.3.2 State Govt Bans Sale of Mahyco Bt-Cotton Seeds

The state government's Department of Agriculture was receiving complaints regarding the substandard bacillus thuringiensis (Bt) cotton seeds. So they withdrew the licence of Mahyco-Monsanto Biotech (MMB). This being the first Bt-cotton seed manufacturing company to be banned by the state as the seeds have resulted in a stagnant yield and led to new pest and disease attacks.

23.13.4 Monsanto

Monsanto is an American multinational agricultural biotechnology corporation. It is one of the pioneer companies in the field of applying biotechnology to agriculture. It is a leading producer of the herbicide glyphosate and genetically engineered (GE) seed. Its headquarters is situated in Creve Coeur, Missouri.

The standard biotechnology industry business model, in which patent rights play a key role was brought up by this company. Conflict created when this business model was applied to agriculture, along with a growing movement to create a global, uniform system of plant breeder's rights in the 1980s. The role of Monsanto in these changes in agriculture (which include its litigation and its seed commercialisation practices) has generated controversy for Monsanto. Monsanto has patent of Cry-I Ac gene.

23.13.5 MAHYCO: Maharashtra Hybrid Corporation

Mahyco was founded in 1964. Its headquarters is located in Jalna. In 1985, it released the first cotton hybrid MECH1. In 1989, Mahyco won the National Award for Research and Development from the Government of India. Mahyco released a grant of ₹3 crore to fund the research programme of rice in ICAR. It encourages cultivators to grow seeds. Currently, more than 10,00,000 cultivators are associated with it in the field of research, development, production, processing and marketing of 115 products in 30 crop species, which includes cereals, oilseeds, fibre crops and vegetables. The technology of this company has created a global benchmark with its high-quality hybrid/open pollinated seeds. Mahyco collaborated with academia and industry for new developments in the field of agri-business. Its association with Monsanto for using the Bt technology for cotton in 1998 is one such excellent example.

3.14 TERMINATOR GENE AND TERMINATOR SEEDS

It is a precise genetic sequence inserted into a seed's DNA. A synthetic chemical (tetracycline) activated the Terminator gene to produce toxins, which kill the embryo and seed will become sterile. The technology in the patent could be applied in a number of ways. Farmers plant the seeds, grow plants and harvest the crops, but due to Terminator gene, the seeds that are harvested will be sterile and cannot be used again for agricultural purpose. This will have adverse effect on the farmers of developing countries, since it forces the farmers to buy new seeds every season.

Note: In March 2006, at the Cop-8 meeting of the UNCBD (United Nation Convention on Biodiversity) terminator seeds were totally prohibited. India and Brazil have passed national laws to prohibit this technology for farmer concern. So, in India, terminator seeds never grow for any crop. Terminator seeds were initially developed as a concept by United States Department of Agriculture and Multinational seed companies. They had not been commercialised anywhere in the world due to opposition from farmers, indigenous people, NGOs and some governments.

23.15 GENETIC ENGINEERING APPRAISAL COMMITTEE (GEAC) AND ITS IMPORTANCE IN INDIA

Genetic Engineering Appraisal Committee, constituted under Ministry of Environment, Forest and Climate Change, with a role to manufacture, use, import, export and store hazardous micro-organisms/genetically engineered organisms. GEAC was setup under the Environment Protection Act, 1986.

This committee is responsible for judging the importance of hazardous living micro-organisms and recombinants in research and industrial production from the environmental perspective. And also looks for the product in market involving therapeutic applications before and after release. GEAC also plays a vital role in releasing the genetically modified product for trial, i.e., in an experiment field as well as a final product. This committee or any member also has a right to punish someone found guilty for environmental damage under the Environment Protection Act, 1986.

23.16 MOLECULAR FARMING (BIOPHARMING) AND EDIBLE VACCINE

Under molecular farming, genetically engineered crops are used to produce various chemical compounds in plants with the help of recombinant DNA technology for therapeutic value (drug production).

Different types of therapeutic proteins form, like antibodies, blood products, growth factors, hormones, recombinant enzymes and various human and veterinary vaccines.

Edible vaccine is derived through genetically engineered expression of an antigenic protein by an edible plant. In its consumption, these recombinant proteins involve in the immune of living beings.

Plant-derived vaccine production system has many advantages over animal-derived vaccines that are used in the generation of immunoglobulin and interferon (antiviral proteins).

First edible vaccines were produced in tobacco in 1990. In the leaves and seeds of transgenic tobacco, recombinant proteins were synthesised which are used against Hepatitis B antigen. In potato, banana, carrot, tobacco, maize, etc., various types of edible vaccines are developed. Vaccine against cholera is also successfully developed in potato.

Various Advantages of Edible Vaccines

- These are easy to produce at bulk level. Their production is cheap and much easier in consumption. Compared to injections, edible vaccines are stable at room temperature but traditional vaccines have a need of refrigeration.

23.17 SILENCED GENES/GENE SILENCING/POST TRANSCRIPTIONAL GENE SILENCING (PTGS)

Gene silencing is a unique phenomenon of **switching off the expression of a gene.** It is a method which reduces or eliminates the protein production from its corresponding gene.

- Proteins are vital molecules, which carry out various functions such as signalling between cells, speeding up biochemical reactions, and providing structural support for the cell. Each gene is responsible for producing a corresponding protein in a two-step process.
- Initially, the information copy programmed in a gene is prepared in the messenger RNA form (mRNA), by a process known as transcription. This occurs in the nucleus of the cell, the cellular structure where all of the cell's genetic material is contained. The mRNA subsequently travels out of the nucleus, and the genetic information it carries is used to produce a specific protein, a process known as translation.
- Gene silencing is often considered the same as gene knockout. **When genes are silenced, their expression is reduced, whereas when genes are knocked out, they are completely erased from the organism's genome and, thus, have no expression.**
- Methods using gene silencing are often considered better than gene knockouts, since they allow researchers to study essential genes that are required for the animal models to survive and cannot be removed.
- There are **many different transcriptional and post-transcriptional processes that can lead to gene silencing.** Generally, gene silencing can be of two types: Transcriptional and Post-Transcriptional.
- Presently, there are numerous gene silencing methods used in research and being formed as possible disease therapeutics and almost all engage in the disabling function of mRNA through avoiding it from translating into a protein like cancer therapy etc.
- **Post Transcriptional Gene Silencing (PTGS) has a major role in plants as a defence mechanism or resistant against, bacteria, viruses and viroids etc.,** for genome stability, and regulation of endogenous gene expression.
- Some of the major applications of the PTGS mechanisms include the antisense RNA approach for the development of Flavr tomato, the development of blue roses by using iris gene, making cotton seeds edible by silencing the genes involved in the production of toxin gossypol, shutting down of the lachrymatory factor synthase gene, in order to produce tearless onion, repression of theobromine synthase coding gene to produce decaffeinated coffee.
- Post Transcriptional Gene Silencing (PTGS) is one mechanism that degrades specific messenger RNAs and thereby reduces the expression of a specific gene.
- Post-Transcriptional Gene Silencing (PTGS) in plants is an RNA-degradation mechanism.

23.17.1 Post-Transcriptional Gene Silencing (PTGS) Mechanisms in Crops

Blue rose Over many years, breeders have tried to produce true blue roses. The CSIR-developed RNAi technology has been used for **removing the gene encoding enzyme dihydroflavonol reductase (DFR)** in roses during its initially commercial plants applications. The **'blue' was the delphinidin gene that was cloned from a pansy,** for directing the synthesis of pigment in the rose into the 'blue' pathway. The silencer gene exploited a cellular phenomenon called **RNA interference (RNAi), which switched off the DFR gene in a red rose,** to block the cyaniding pathway, and then install the delphidin gene – plus a new DFR gene to complete delphinidin synthesis.

Edible cotton seeds To make cotton seed edible, researchers **reduced its toxic gossypol level** by RNA interference (RNAi). The Texas A&M University scientists have worked upon reducing the toxic chemical levels in cotton, thereby moulding the seeds edible and transforming the cotton into an important new source of food.

Tearless onion Gene-silencing technology, RNAi allows retargeting the plant's own natural regulation system without expression of foreign proteins in the plant. **Through RNAi genes, lachrymatory factor synthase gene stop the synthesis of sulphur compounds** those converted to the tearing agent.

Decaffeinated coffee The demand for decaffeinated coffee is increasing as the caffeine stimulatory effects are adversely affecting susceptible individuals through **triggering palpitations, increasing blood pressure and insomnia.** Three N-methyltransferase enzymes are there in caffeine biosynthesis coffee plants – CaXMT1, CaMXMTi (theobromine synthase) and CaDXMT1 (caffeine synthase) – which sequentially add methyl groups to xanthosine transforming it into caffeine. **The coffee plants were modified, in which expression of theobromine synthase (CaMXMTi) is repressed by RNA interference (RNAi). The plants' caffeine content is decreased up to 70 per cent.**

Opium poppy Opium poppy (*Papaver somniferum*) is also an example in gene silencing usage. The silencing of **codeinone reductase (COR) gene in the opium poppy using RNA interference (RNAi) is designed to silence** all members of the multigene COR family for causing the high-yield accumulation of the non-narcotic alkaloid reticuline.

Flavr savr tomato It is a genetically changed tomato produced by Calgene and carries an **antisense RNA, thereby inhibiting the gene expression causing the softening of fruit;** thus, it stays firm longer. This gives the producers a larger transportation time and the mechanical harvesting opportunity with little bruising.

23.18 IVF (IN VITRO FERTILISATION) AND TEST TUBE BABY

In Vitro Fertilisation

In Vitro Fertilisation (IVF) is the fertilisation of an egg and sperm outside the mother's body. The process involves stimulating a women's adulatory process, removal of egg or eggs from her ovaries and letting the sperm fertilise them in a liquid in a laboratory and hence requires efficient monitoring. The resultant zygote is cultured for 2–6 days in a growth medium (blastocyst stage) and is then transferred to the same or another women's uterus, with the intent to establish a successful pregnancy.

It can help overcome female infertility caused due to problems with the Fallopian tubes (it is a natural place inside mother body where fertilisation occurs), which makes fertilisation difficult. It can also serve to be useful in cases of male infertility caused due to defect in sperm quality. It helps infertile couples so that they can have a baby of their own (with their own eggs and sperm). Without using donor egg or donor sperm, DNA of the zygote will be of intended parents only.

This treatment is a good option for those who are facing either of the following mentioned problems:

- Blocked Fallopian tubes
- Low sperm numbers or motility
- Infrequent or absent ovulation
- Endometriosis
- Unexplained infertility
- Age-related infertility
- Failure of other fertility treatments such as IVI

Test Tube Baby

Test Tube Baby (also called in vitro fertilisation) is a revolutionary treatment which enables couples with different types of infertilities, to conceive a baby. Developed by Robert G. Edwards and Patrick C. Steptoe of Great Britain, the technique was devised to help in case of damaged female's Fallopian tubes or when a male's sperm count is low. In recent times, its application has increased, which now includes prospective parents with other reproductive problems (e.g., inability to produce eggs, poor sperm quality, etc.).

Test tube baby refers to a child, conceived outside the women's body. Eggs removed from the mother's ovary are incubated with the sperm from the father. Now, they are allowed to divide until the Blastula stage (64–128 cell structure), which usually takes 3–4 days, which is then transferred to the mother's or a surrogate's uterus to develop normally. Drugs are induced to the patient's ovaries to grow several mature eggs rather than a single one that develops each month. If more than one egg is fertilised and transferred to a uterus, chances of success increases.

In 1978, Steptoe and Edwards successfully carried out the birth of the world's first test tube baby, 'Louis Joy Brown' in United Kingdom, whose mother had Fallopian tube blockages. The second successful test tube baby occurred in India, after 67 days of Louis's birth, named Durga.

Nobel Prize in Physiology or Medicine was awarded to **Robert G. Edwards** in 2010, for co-developing the treatment together. Egg donation and IVF enable women who are past their reproductive years to get pregnant. The record of oldest woman to give birth using IVF and donated egg was held by Adriana Iliescu in 2004, at the age of 66.

(Refer **Infographic: In-vitro Fertilisation & Test Tube Baby**)

23.19 SURROGATE MOTHER

In this, a woman carries a baby for a couple who are not able to conceive or carry a child themselves because of medical or physical reasons. The supposed parents become the legal parent(s) of a child born with the help of surrogacy. It is of two types.

Traditional surrogacy is a pregnancy condition where the surrogate is linked genetically to the baby and becomes pregnant with the help of artificial insemination. It used to be common, but today, host surrogacy is most prevalent. Host surrogacy is done through IVF, either through the usage of the supposed mother's eggs or with donor eggs. Thus, the surrogate mother does not make the use of her own eggs and is genetically not linked to the baby. There are three stages in host surrogacy, which are as follows:

- **Egg extraction:** The intended parent (female) undergoes a special procedure to extract a number of eggs.
- **Fertilisation:** The eggs are fertilised with sperm in the laboratory, resulting in embryos.
- **Embryo transfer:** Transfer of embryo into the womb of the surrogate mother.

Surrogacy was initially disclosed to help infertile couples. But, with time, the humanity associated with its discovery is lost. The greediness in humans makes both the 'child' and the surrogate mother a 'commodity in demand'. With time, many ethical issues were discovered related to surrogacy and loop holes in laws allowed the unethical behaviour flourish.

Even before the IVF technology surrogacy was known and traditional surrogacy was popular, this kind of surrogacy not only objectified the child and the borrowed womb but also sidelined the legal mother. As the surrogate mother was not gestational mother but also the genetic mother of the child, this was more of an emotional and mental suffering for the legal mother as her existence has no role in the development (Zygote Embryo Infant) of the child.

Once IVF gained popularity, the exploitation of womb shot up. People rented womb by force, development of agencies for surrogacy, etc., increased. With this, India became a hub as willingness for surrogacy was maximum and price charged for this was very low (compared to other nations) and the success rate was also high.

And then, the society witnessed issues such as citizenship of the child (when the nation of the surrogate and the nation of the legal parents both deny to accept the child as a citizen), acceptance of the child (in cases of those couples who went for surrogacy got divorced before delivery and denied to accept the child and even the surrogate refuse to accept), no payment after (especially in the cases where the child is born still or dead or born with disorder either mental or physical) families with financially low background forcing their women to take surrogacy and so on.

Looking at this, India has recently altered its surrogacy law to stop the commercialisation and exploitation of surrogacy both by normal citizens and people from medical stream.

23.19.1 Select Committee Recommendations on Surrogacy (Regulation) Bill

- 15 major changes have been suggested in a report presented by the Select Committee on *Surrogacy (Regulation) Bill.*
- The bill *prohibits commercial surrogacy and allows only altruistic surrogacy.*

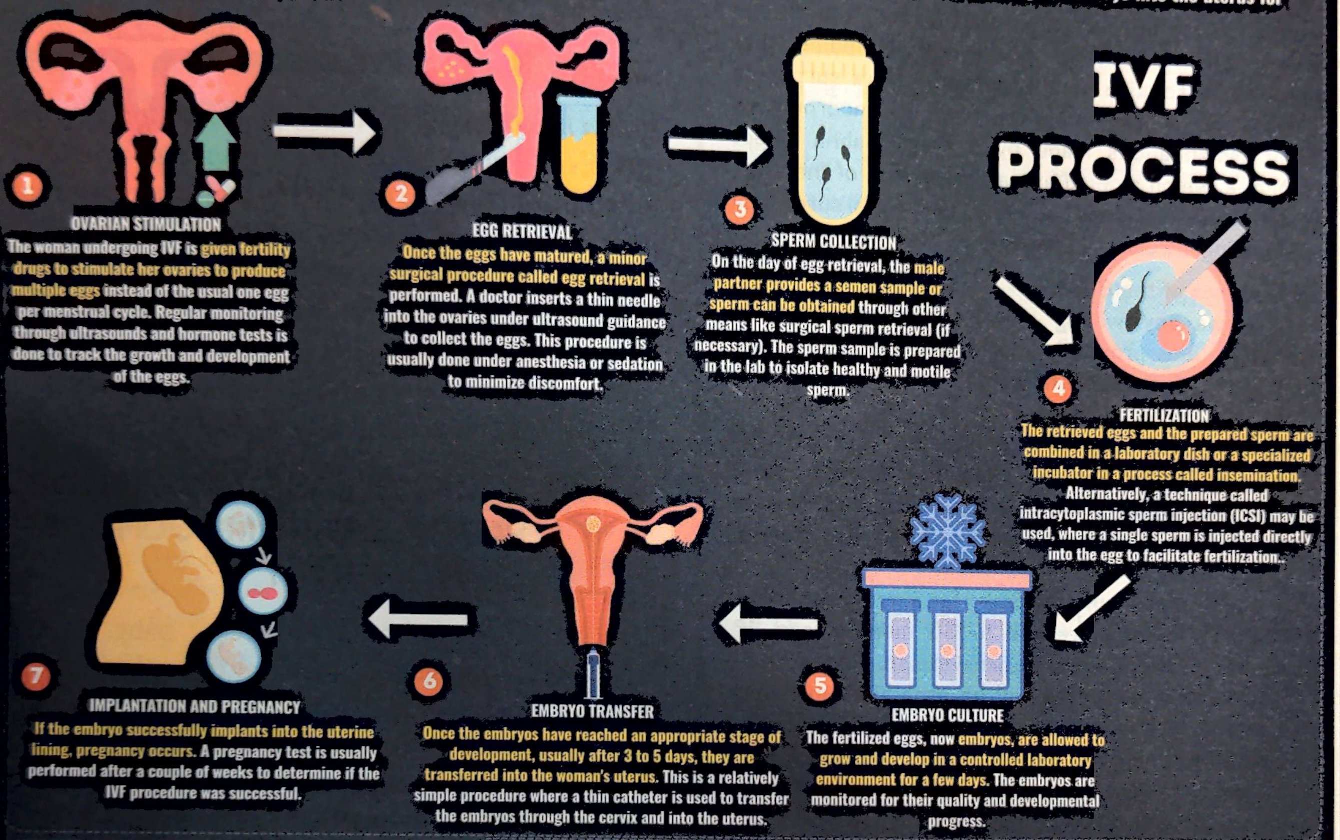
Background

- The Bill was passed by the Lok Sabha in August 2019, but had to be referred for re-assessment to the select committee in November 2019, as several Rajya Sabha members found certain clauses contentious such as allowing only altruistic surrogacy with a near relative as a surrogate.

(IVF) IN-VITRO FERTILIZATION

In-vitro fertilization (IVF) is a medical procedure used to assist individuals or couples who are facing difficulties in conceiving a child naturally. IVF involves combining an egg and sperm outside the body in a laboratory setting, creating an embryo, and then transferring the embryo into the uterus for implantation and potential pregnancy.

IVF PROCESS



1 **OVARIAN STIMULATION**

The woman undergoing IVF is given fertility drugs to stimulate her ovaries to produce multiple eggs instead of the usual one egg per menstrual cycle. Regular monitoring through ultrasounds and hormone tests is done to track the growth and development of the eggs.

2 **EGG RETRIEVAL**

Once the eggs have matured, a minor surgical procedure called egg retrieval is performed. A doctor inserts a thin needle into the ovaries under ultrasound guidance to collect the eggs. This procedure is usually done under anesthesia or sedation to minimize discomfort.

3 **SPERM COLLECTION**

On the day of egg retrieval, the male partner provides a semen sample or sperm can be obtained through other means like surgical sperm retrieval (if necessary). The sperm sample is prepared in the lab to isolate healthy and motile sperm.

4 **FERTILIZATION**

The retrieved eggs and the prepared sperm are combined in a laboratory dish or a specialized incubator in a process called insemination. Alternatively, a technique called intracytoplasmic sperm injection (ICSI) may be used, where a single sperm is injected directly into the egg to facilitate fertilization..

5 **EMBRYO CULTURE**

The fertilized eggs, now embryos, are allowed to grow and develop in a controlled laboratory environment for a few days. The embryos are monitored for their quality and developmental progress.

6 **EMBRYO TRANSFER**

Once the embryos have reached an appropriate stage of development, usually after 3 to 5 days, they are transferred into the woman's uterus. This is a relatively simple procedure where a thin catheter is used to transfer the embryos through the cervix and into the uterus.

7 **IMPLANTATION AND PREGNANCY**

If the embryo successfully implants into the uterine lining, pregnancy occurs. A pregnancy test is usually performed after a couple of weeks to determine if the IVF procedure was successful.

RISKS

- IVF involves large amounts of physical and emotional energy, time, and money. Many couples dealing with infertility suffer stress and depression.
- A woman taking fertility medicines may have bloating, abdominal pain, mood swings, headaches, and other side effects.
- Repeated IVF injections can cause bruising.
- In rare cases, fertility drugs may cause ovarian hyperstimulation syndrome (OHSS). This condition causes a buildup of fluid in the abdomen and chest. Symptoms include abdominal pain, bloating, rapid weight gain (10 pounds or 4.5 kilograms within 3 to 5 days), decreased urination despite drinking plenty of fluids, nausea, vomiting, and shortness of breath. Mild cases can be treated with bed rest. More severe cases require draining of the fluid with a needle and possibly hospitalization.
- Risks of egg retrieval include reactions to anesthesia, bleeding, infection, and damage to structures surrounding the ovaries, such as bowel and bladder.
- There is a risk for multiple pregnancies when more than one embryo is placed into the womb. Carrying more than one baby at a time increases the risk for premature birth and low birth weight. (However, even a single baby born after IVF is at higher risk for prematurity and low birth weight.)
- IVF is very costly.

TEST-TUBE BABY

- A test-tube baby is a term used to describe a baby born through medical intervention rather than natural sexual intercourse.
- It originally referred to babies born from early artificial insemination methods and now includes babies born through in vitro fertilization (IVF), where the egg is fertilized outside the woman's body. The use of this term has sparked discussions and controversies surrounding the ethics of reproductive technologies. Its evolution reflects the changing perception of our ability to manipulate human embryos.
- The first successful artificial insemination leading to a test-tube baby was performed by William Pancoast in 1884. However, the significance of this event was not widely recognized by the public or media at the time.
- On July 25, 1978, Patrick Steptoe and Robert Edwards, two British medical researchers, achieved the first successful birth of a baby conceived through in-vitro fertilization (IVF).
- This breakthrough gave concrete realization to the revised definition of a test-tube baby. Louise Brown, the first baby born via IVF, garnered significant media attention, with newspapers reporting it as a groundbreaking scientific and medical achievement. Tabloids treated the birth like the arrival of a new celebrity. The diverse media response foreshadowed the varied public reactions that would follow. The birth of Louise Brown sparked discussions on legal and ethical implications, both in international media and scientific journals, which continue to this day as ongoing research explores new reproductive practices.

IVF AND INDIA

- The development of IVF in India was a contested and complex process. Practitioners sought credit and credibility, leading to disputes over the first "test-tube baby" in the country.
- Media played a crucial role in shaping the narrative and resolving these controversies. The article highlights the interplay between scientific knowledge, media representation, and the pursuit of credibility.
- In India, the birth of the first scientifically documented test-tube baby, Harsha, on August 6, 1986, marked the country's entry into the world of assisted conception.
- This term, "scientifically documented," was emphasized to distinguish it from a similar claim made by Dr. Subhas Mukerji in 1978, shortly after the birth of the world's first test-tube baby, Louise Brown, in the UK.
- Dr. Mukerji claimed the birth of the world's second test-tube baby in 1978, but his announcement lacked scientific documentation.
- Dr. TC Anand Kumar later produced India's first scientifically documented IVF baby, Harsha, in Bombay. Kumar's team considered Harsha as the first scientifically supported test-tube baby due to limited information on Mukerji's work.

SURROGACY (REGULATION) BILL, 2020

Union Cabinet has approved **the Surrogacy (Regulation) Bill, 2020.** The amended bill is reformed version of the draft legislation which was passed by Lok Sabha in August 2019 but **its provisions, including that only a close relative of a couple can be a surrogate mother, had invited criticism.** The bill incorporates all recommendations made by a Rajya Sabha select committee, which studied an earlier version of the draft legislation, and is aimed at banning commercial surrogacy and allowing altruistic surrogacy.

Key Features of the Bill

1. It allows **any 'willing' woman to be a surrogate mother** and proposes that widows and divorced women can also benefit from its provisions, besides infertile Indian couples.
2. The bill also proposes to regulate surrogacy by establishing **National Surrogacy Board** at the central level and, **State Surrogacy Board and appropriate authorities in states and Union Territories, respectively.**
3. The proposed **insurance cover for surrogate mother has now been increased** to 36 months from 16 months provided in the earlier version.
4. **Commercial surrogacy will be prohibited** including sale and purchase of human embryo and gametes.
5. **Ethical surrogacy** to Indian married couples, Indian-origin married couples and Indian single woman (only widow or divorcee between the age of 35 and 45 years) will be allowed on fulfillment of certain conditions.

Key Recommendations

1. Keep an ***option for compensating the surrogate mother beyond medical expenses and insurance coverage*** that includes taking care of her nutritional food requirements, maternity wear, etc., that is vital for the well-being and upkeep of the surrogate mother.
2. The controversial ***clause of 'close relative'*** has been done away with and instead the committee has recommended the term to be replaced with a 'willing woman'.
3. ***Who can opt?*** Single women, including a widow and divorcee, between the ages of 35 and 45 years, should be able to opt for surrogacy.
4. ***Increase insurance cover*** for the surrogate mother from the 16 months proposed in the Bill to 36 months.
5. In order to protect the interests of the child born through surrogacy, the order regarding the parentage and custody of the child, issued by a Magistrate, shall be ***the birth affidavit for the surrogate child.***

23.19.2 Need for Regulation

India has emerged as a surrogacy hub for couples from other countries and there have been reports concerning unethical practices, exploitation of surrogate mothers, abandonment of children born out of surrogacy, and rackets involving intermediaries importing human embryos and gametes. ***The 228th report of the Law Commission of India*** has recommended prohibiting commercial surrogacy and allowing altruistic surrogacy by enacting suitable legislation.

23.20 PRONUCLEAR TRANSFER/THREE PARENTS BABY/MITOCHONDRIAL GENE THERAPY

In the concept of a three-parents baby, a baby is conceived using genetic material from three people in which mitochondrial DNA (a small part in a cell that helps your baby to turn food into energy) from a female is used to replace faulty material mitochondria and thus prevent inherited diseases.

In this technique, doctors will replace an egg's defective mitochondrial DNA (those are present in egg cytoplasm) with a female donor's healthy DNA. This will prevent children from suffering from debilitating conditions such as muscular dystrophy, etc., which are inherited through cytoplasm.

Mitochondria is one of the cell organelles that is passed from mother to child due to cytoplasm inheritance (all male and female receive mother's cytoplasm and egg nucleus + father sperm nucleus, inside zygote). Mutations in the 37 genes in the mitochondria can produce fatal inherited diseases. There is no cure or effective treatment for many of the mitochondrial diseases.

23.20.1 Procedure of Mitochondrial Gene Therapy

Where can we Produce Three-Parent Baby?

- Clinics in Britain can now apply to create three-parent babies after the fertility final approval for the procedure.

- The British scientists created a fertility technique, which assists the doctors in replacing an egg's defective mitochondrial DNA with a female donor's healthy DNA. This will prevent children from suffering debilitating conditions such as muscular dystrophy.
- They said that procedure could go ahead when options like screening and others have proved futile.

23.20.2 Legalisation

The UK is the first country to legalise the procedure. Although, in 2016, the first baby was born using mitochondrial replacement in Mexico.

The world's first three-parent baby has been born in **Mexico** with the help of a controversial new fertility technique that incorporates DNA from three people. The 'three-parent' technique allows parents with rare genetic mutations to have healthy babies. **The boy's mother carries genes for Leigh syndrome, a fatal disorder that affects the brain, muscles and nerves of developing infants.** Genes for the disease reside in DNA in the mitochondria, which provide energy for our cells. The resulting egg – with nuclear DNA from the mother and mitochondrial DNA from a donor – was then fertilised with the father's sperm.

3 Many Pros and Cons in Mitochondrial Gene Therapy

- However, critics said the technique was 'dangerous', 'needless' and 'ethically reckless'.
- Dr. David King, director of the secular pro-choice watchdog group, Human Genetics Alert said 'This decision to approve experiments on babies, using this dangerous and medically unnecessary technology risks all our children's futures'.
- It opens the door to designer babies.
- Throughout the process, the campaigners for approval of this technology have relied on shameless emotional blackmail.

(Refer **Infographic: Pronuclear Transfer / Three Parents Baby**)

23.21 TISSUE CULTURE

Tissue culture is a method used to **produce plants under sterile conditions** also known as **micro propagation.** In this technique, a plant explants (plant parts) or seeds are used, which have been sterilised before. They are put in containers with a growing medium (usually a gel) with some nutrients added.

Plant tissue culture enables to grow exact copies of the donor plant. Those plants that have genetically desirable traits can lead to several clones of a particular plant, at a faster rate than traditional propagation methods like cuttings, pulling or divisions.

'Toshio Murashige' (a scientific pioneer in this field), Professor Emeritus of the University of California at Riverside defined four stages of plant tissue culture.

Stage I	Prepare an aseptic (sterile) culture.
Stage II	The multiplication of propagules (any part of a plant used to make or become new plants).
Stage III	Preparation for successful transfer of propagules to soil, for successful transfer to soil (rooting and 'hardening' (acclimating) outside of sterile conditions in regular growing media).
Stage IV	Establishment in soil (or other appropriate growing medium).

Animal Tissue Culture

It is the biological technique in which scientists take a piece of tissue from an animal specimen, grow and maintain the cells from that tissue in an in vitro or artificial environment. Stem cell technology will also be considered under tissue culture. Contamination-free laboratory conditions should be maintained to mimic the original environment. It grows in a flask containing media, which is enriched with nutrients and growth factors to provide nutrition, which are kept in incubators that regulate temperature and humidity. Mimicking the environment in the lab allows the scientists to study them in controlled conditions.

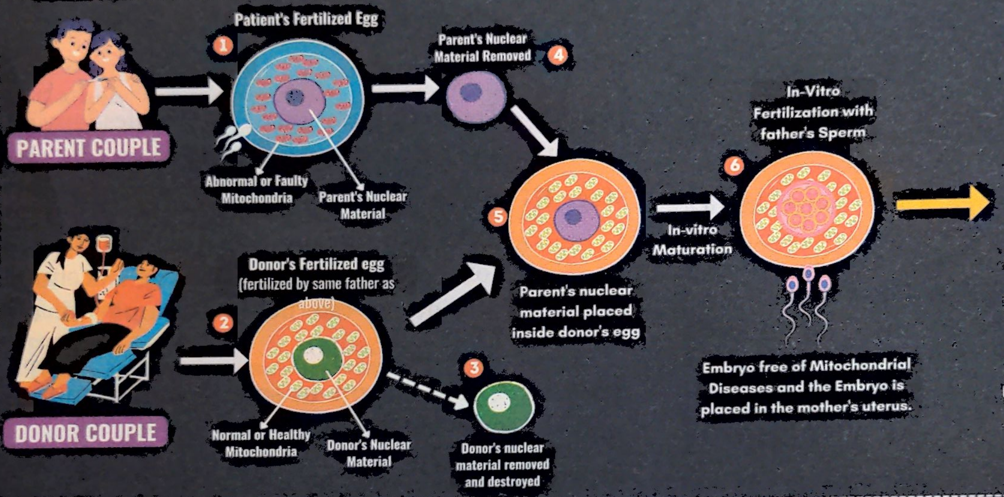
It is used for culturing cells in laboratory experiments. It is helpful in learning more about cells, organ structures and functions, diagnose viruses, the effects and toxicity of drugs, developing the treatments to organ failure and much more. Products developed from cell culture include vaccines, hormones, enzymes and anticancer drugs, etc.

23.22 GENE THERAPY

In the process, genetic material is transferred into a person's cells to provide immunity against diseases.

PRO-NUCLEAR TRANSFER

- Pronuclear transfer is a specialized technique used in assisted reproductive technology (ART) to prevent the transmission of certain genetic disorders from parents to their offspring.
- It is primarily employed in cases where the mother carries a mitochondrial DNA (mtDNA) mutation that can cause severe mitochondrial diseases.
- Mitochondria are small structures within cells that are responsible for producing energy. They contain their own set of DNA, known as mitochondrial DNA, which is separate from the nuclear DNA found in the cell's nucleus. Mitochondrial diseases are genetic disorders caused by mutations in the mitochondrial DNA, leading to impaired energy production and potentially affecting various organs and systems in the body.
- By transferring the pronucleus from the couple's embryo into the donor's enucleated egg, the resulting embryo carries the nuclear DNA from the intended parents but acquires healthy mitochondria from the donor. This technique aims to prevent the inheritance of mitochondrial diseases while preserving the genetic information of the intended parents.
- It's worth noting that pronuclear transfer is a highly specialized and regulated procedure that requires significant expertise and ethical considerations. Its primary purpose is to help couples with a high risk of passing on severe mitochondrial diseases to have healthy offspring.
- Mitochondrial diseases are genetic disorders caused by abnormalities in the mitochondria, the energy-producing structures within cells. They can affect multiple organs and systems due to impaired energy production. These diseases arise from mutations in mitochondrial DNA (mtDNA), separate from the DNA in the cell's nucleus. The resulting dysfunction in mitochondria leads to various symptoms and health issues.


Patient's Fertilized Egg
1
PARENT COUPLE
Abnormal or Faulty Mitochondria
Parent's Nuclear Material
Parent's Nuclear Material Removed
4
Donor's Fertilized egg (fertilized by same father as above)
2
DONOR COUPLE
Normal or Healthy Mitochondria
Donor's Nuclear Material
3
Donor's nuclear material removed and destroyed
5
Parent's nuclear material placed inside donor's egg
In-vitro Maturation
In-Vitro Fertilization with father's Sperm
6
Embryo free of Mitochondrial Diseases and the Embryo is placed in the mother's uterus.

1. A couple seeking to have a child undergoes standard IVF treatment, where the woman's eggs are harvested and fertilized with the man's sperm in a laboratory setting.
2. Simultaneously, a healthy egg donor provides her eggs for the procedure. These eggs will serve as the source of healthy mitochondria.
3. The donor's eggs are also retrieved, and the pronucleus, which contains the nuclear DNA, is removed from each of her eggs.
4. The pronucleus from the couple's fertilized embryo is also extracted.
5. The pronucleus from the donor egg is then transferred into the enucleated recipient embryo, replacing the couple's pronucleus.
6. The reconstructed embryo, now containing the couple's nuclear DNA and healthy donor mitochondria, is implanted into the woman's uterus for potential implantation and pregnancy.

PURPOSE

Prevention of Mitochondrial Diseases

- Mitochondrial diseases are genetic disorders that affect the function of mitochondria, the powerhouses of the cells responsible for generating energy.
- These diseases can cause a wide range of symptoms, including muscle weakness, organ dysfunction, neurological problems, and even life-threatening conditions.
- It aims to prevent the transmission of mitochondrial diseases from the mother to her child by replacing the faulty mitochondria in the mother's eggs with healthy mitochondria from a donor.

Genetic Relatedness

- For women with mitochondrial disorders, Pronuclear Transfer offers the possibility of conceiving a child who is genetically related to them.
- By transferring the nucleus from the mother's fertilized egg to a donor's egg, which has healthy mitochondria, the resulting hybrid egg contains the genetic material of the intended parents.
- This allows the parents to pass on their nuclear DNA while minimizing the risk of transmitting mitochondrial diseases.

Family Building Options

- Pronuclear Transfer expands the reproductive options for individuals and couples affected by mitochondrial disorders.
- It provides an alternative to traditional IVF (in-vitro fertilization) methods, which may result in passing on mitochondrial diseases to the offspring.
- By offering the chance to have a child without the risk of severe mitochondrial disorders, Pronuclear Transfer can bring hope and alleviate the concerns associated with these conditions.

Research and Advancements

- Another purpose of Pronuclear Transfer is to further research and develop techniques in the field of assisted reproductive technology (ART).
- Ongoing studies and evaluations of the safety and effectiveness of Pronuclear Transfer contribute to the advancement of reproductive medicine, potentially leading to improved outcomes and expanded options for individuals and couples facing mitochondrial diseases.
- It's important to note that Pronuclear Transfer raises ethical and legal considerations, and its use is subject to regulations and guidelines established by regulatory bodies in each country.

WHAT IS 3-PARENT BABY?

- A "three-parent baby" refers to a child conceived through a specialized assisted reproductive technology technique known as mitochondrial replacement therapy (MRT) or mitochondrial donation.
- In this process, genetic material from three individuals is involved in the creation of an embryo. The nuclear DNA (containing the majority of the genetic material) comes from the mother and father, as in traditional reproduction.
- However, the mother's defective or mutated mitochondrial DNA (mtDNA), which is responsible for energy production within cells, is replaced with healthy mtDNA from a donor, usually a second woman.
- This procedure aims to prevent the transmission of certain mitochondrial diseases from the mother to the child. It is important to note that this technique is still relatively new and has been approved for use in a limited number of countries for specific cases.

WHAT IS MITOCHONDRIAL GENE THERAPY?

- Mitochondrial gene therapy aims to treat or prevent mitochondrial diseases by modifying the genetic material within mitochondria. It involves gene editing or transfer techniques to correct or eliminate disease-causing mutations in mitochondrial DNA. This experimental approach is still in the early stages of development and requires further research for clinical use.

PROS

- Prevention of severe mitochondrial diseases.
- Expanded reproductive options for at-risk couples.
- Improved quality of life for individuals by avoiding debilitating diseases.
- Potential for scientific advancement and further research.

CONS

- Ethical concerns surrounding manipulation of embryos.
- Safety considerations and unknown long-term effects.
- Genetic implications and inheritable changes to mitochondrial DNA.
- Regulatory challenges and inconsistent guidelines.

Gene therapy is an extremely useful tool for numerous diseases, like severe combined immune-deficiencies, haemophilia, Parkinson's disease, cancer, etc., and a **carrier known as a 'vector' is used to deliver a gene into a cell. Viruses are the most common type of vectors used in gene therapy.** Before using in therapy, vectors should be altered to make them safe, although some risks still exist with gene therapy.

Gene therapy is the method of introduction, manipulation, or deletion of genes within an individual's cells or biological tissues for the treatment of diseases. Most common form of gene therapy is the insertion of functional genes to replace a mutated gene, and in some cases, directly correcting the mutation or modifying normal gene to cure the diseases, such as cystic fibrosis, haemophilia, muscular dystrophy and sickle cell anaemia. Gene therapy can be classified as follows:

1. Germ Line Gene Therapy

In this type of therapy, **Germ cells, (i.e., sperm or eggs), are modified by the insertion of functional genes, which are added into their genomes.** The change occurring in the genome due to therapy would be heritable and would be passed on to later generations. This new technique is highly effective to fix the genetic disorders and hereditary diseases. On the other side, many jurisdictions forbid the use of this application, in human beings, at least for the present, due to numerous technical and ethical reasons.

2. Somatic Gene Therapy

The therapeutic genes are introduced into the somatic cells of a patient, in this gene therapy. Any modifications will be restricted to individual patient only, without any chances of being inherited by the next generations of the patient.

Problems and Ethics of Gene Therapy

- **Short-lived nature of therapy:** The therapeutic DNA transferred into target cells must remain functional and the cell containing therapeutic DNA need to be stable and long lived. Problems with inserting therapeutic DNA into the genome and the fast dividing nature of many cells check gene therapy from achieving any long-term benefits; as a result, patients undergo multiple rounds of gene therapy.
- **Immune response:** Whenever a foreign entity is introduced into human body (cell or tissues), the immune system attacks the invader. When a foreign segment of DNA is introduced in the body for gene therapy, there is always a possibility of risk that immune system reduces the gene therapy's effectiveness. Besides this, the immune system has also improved the response against invaders that it has seen before and thus, it becomes difficult for gene therapy to be repeated in patients.
- **Problems with viral vectors:** Viruses are the carrier of choice in most gene therapy studies. When we choose virus as a vector for gene therapy, it shows many problems to the patient, such as toxicity, immunity and inflammatory responses, and gene control, etc. There is always the probability that the viral vector, inside the patient, may recover its ability to cause disease.
- **Chance of inducing a tumour:** If the DNA segment is introduced in the incorrect place in the genome, for instance in a tumour suppressor gene, a tumour can be induced.

Note: Misuse of gene therapy in the form of gene doping, which athletes resort to, for increasing their physical stamina.

23.23 GENE EDITING AND CRISPR TECHNOLOGY

Gene Editing

The bio-information that defines any individual is contained in genes. Physical characteristics like skin or hair colour, more subtle features and even behavioural traits can be ascribed to information encoded in the genetic material.

With ability to alter this information, scientists try to control some of these features. It is not a new phenomenon but sometimes expressed with terms like genetic modification, genetic manipulation or genetic engineering.

CRISPR-Cas9

The **clustered, regularly interspaced, short palindromic repeats,** or CRISPR/CRISPR-associated protein 9 (Cas9) (CRISPR-Cas9) system has made genetic manipulations and gene editing simpler, faster and easily available to most laboratories.

CRISPR technology, a gene-editing technology can be utilised for different purposes like altering genetic expression or changing the genome of an organism.

- Targeting specific stretches of an entire genetic code or editing the DNA at particular locations can be done through this technology.
- CRISPR technology is an important tool for genome editing. Now researchers will be able to easily alter DNA sequences and modify gene function.
- It can be used for correcting genetic defects, treating and preventing the spread of diseases and improving crops. However, its promise also raises ethical concerns.

How it Works?

This technology works like a cut-and-paste mechanism on DNA strands that contain genetic information.

- The DNA strand identifies the specific location of the genetic codes that need to be changed, or 'edited' and then, using the Cas9 protein, which acts like a pair of scissors, that location is cut off from the strand. Once the DNA strand is broken, it has a natural tendency to repair itself.
- During the auto-repair process, scientists intervene by supplying the desired sequence of genetic codes that binds itself with the broken DNA strand.

Issues

Study by Stanford University, US, says that unexpected off-target (outside of the intended editing sites) effects in mice have been introduced by the CRISPR-Cas9 system. There is a fear that the CRISPR system is being impulsively ran for clinical use lingers.

- Studies highlighted that edited cells might trigger cancer.
- It may also increase the risk of mutations elsewhere in the genome in those cells.
- Although CRISPR-Cas9 technology has been successfully used to cure several diseases however, there remains many a things which are not clear like how we can determine which disease or traits are suitable for gene editing.
- There are ethical concerns related to manipulation of human embryos for own interest.

Ethical Challenges

- ***Bioethicists expressed concern over the clinical application of such research.*** These are still early days in a new frontier of genome engineering.
- ***Bioethicists fear abuse of gene editing,*** not just by misguided governments but also by the private sector preying on a parent's desire to create a perfect child.
- It can create ***unforeseen changes in the genome which are undesirable.***
- ***It has also been ethically questioned*** whether editing gene to create babies that parents desire would make them more like commodities.
- **Safety:** Safety is of primary concern because of the possibility of off-target effects (edits in the wrong place) and mosaicism (when some cells carry the edit but others do not),
- **Informed Consent:** Some people have a concern that it is impossible to obtain up-to-date consent for germline therapy because the patients affected by the edits are the embryo and future generations.
- Researchers and bioethicists are also concerned about the possibility of obtaining truly informed consent from prospective parents as long as the risks of germline therapy are unknown.
- **Justice and Equity:** As with many new technologies, there is concern that only wealthy people will have the reach to genome editing which will increase existing disparities in access to health care and other interventions. Some worry that a class of individuals defined by the quality of their engineered genome can be created through germline editing.

However, the CRISPR technology is a path-breaking technology, to alter genes in order to tackle a number of conventional and unconventional problems, especially in the health sector. However, experiments and tests to validate its use shall be subjected to appropriate scrutiny by the regulators, and commercial misuse must be prevented.

(Refer **Infographic – CRISPR Technology**)

23.24 GENE DOPING

Altering genes to enhance athletic performance is the reason behind gene doping. In the era of gene therapy, a simplest way in delivering proteins and hormones to an athlete's tissues and organs turned into reality. A substance can change the basic genetic DNA expression such that large growth of muscles, quick recovering and extra forcefully contracting.

The muscles, which are not doped cannot be noticed by anti-doping laboratories, which would be perfect for taking advantage of competition. Gene doping is of two types:

Ex vivo gene doping The method of external gene doping, which consists of initial transferring of gene to cells in culture, then transferring the tissue into the recipient. Once the genes are embedded into the athlete's cell; it releases biochemicals or hormones, thereby increasing the person's performance during competitions.

In vivo gene doping The new gene's deliverance into an athlete can be with the help of physical, biologic or chemical methods. There is biological customisation of viruses, thereby inserting the artificial gene into cells in a particular organ or tissue or into cells right through the competitor's body.

Gene doping is a hazard to the sports integrity and athletes' health, and as the WADA (World Anti Doping Agency), being a worldwide organisation accountable for encouragement, coordination and monitoring the fight against doping in every form of sport, is providing vital resources and awareness to the methods for enabling the detection of gene doping.

German scientists from Tubingen and Mainzhave formed a reliable blood test for detecting gene doping even after 56 days: 'For the first time, a direct method is now available that uses conventional blood samples to detect doping via gene transfer'.

23.25 CLONING

Cloning represents a copy of production of cells or completely desired organisms. Vegetative and asexual reproductions are colonel propagation because they produce a same organism with similar genotype and phenotype. There are different levels of cloning:

1. **Gene/molecular cloning:** This cloning is the amplification of DNA fragments that contain whole genes.
2. **Cellular cloning:** This type of cloning is used in stem cell research, where a population of identical cells form a single cell.
3. **Organism cloning:** In this process, a new multicellular organism is created, which is genetically identical to other organism. It is an asexual method of reproduction. Scientists have made some major achievements in this area, which includes the asexual reproduction of sheep and cows. There is a lot of ethical debate over using cloning. Dolly sheep is an example of organism cloning.

In February 1997, Ian Wilmut and his colleagues at the Roslin Institute, successfully cloned a sheep, from the mammary glands of an adult female. Dolly was the first mammal (although the first clones were frogs) to be effectively cloned from an adult cell. She was cloned at Scotland's Roslin Institute and stayed there since her birth in 1996 until her death in 2003. Scientists at India's National Dairy Research Institute (NDRI), Karnal (Haryana), produced the first cloned buffalo in February 2009, using DNA from the ear of an adult female. Unfortunately, it died of pneumonia soon after its birth.

In genetics and developmental biology, Somatic Cell Nuclear Transfer (SCNT) is a method for the creation of a clonal embryo, with the usage of an ovum with a donor nucleus (Refer **Infographic – Cloning**). This application has lot of application in embryonic stem cell research and in regenerative medicine, where it is sometimes referred to as 'therapeutic cloning'. This was the first step in the reproductive cloning process.

23.25.1 Types of Cloning

There are Two Types of Cloning

(a) **Reproductive cloning:** In this type of cloning, the egg cell is placed into a uterus after few divisions in it. The cell is then allowed to develop into a foetus that is genetically identical to the donor of the original nucleus.

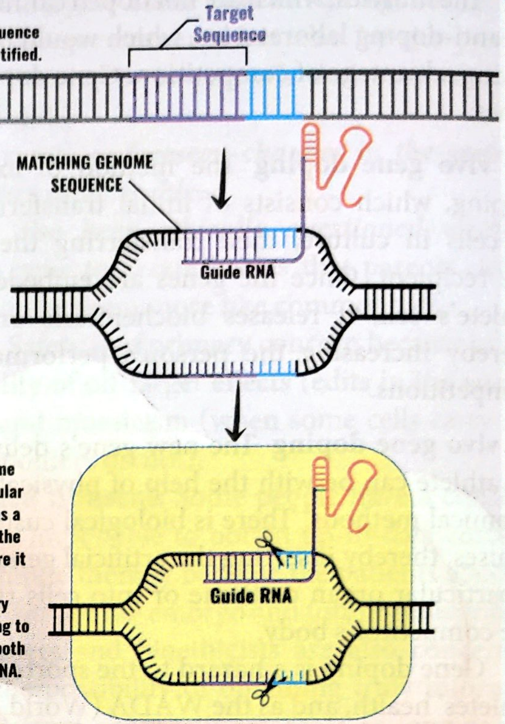
(b) **Therapeutic cloning:** The egg is kept in a petridish for developing into embryonic stem cells, showing potentials for treating several ailments.

Therapeutic Cloning/Biomedical Cloning

The initial stages of this procedure are similar to adult DNA cloning. It aims in producing a healthy replica of a sick person's tissue or organ for transplantation. This technique would be better to rely on for transplanting organs from other people. The tissue or organ contains the sick person's original DNA and the patient does not require to take immunosuppressant drugs for the remaining life, which is currently required during

CRISPR-CAS9

- CRISPR-Cas9 is a revolutionary gene-editing technology that has garnered significant attention and excitement in the scientific community and beyond.
- It allows scientists to make precise changes to the DNA of various organisms, including humans, plants, and animals.
- CRISPR, which stands for Clustered Regularly Interspaced Short Palindromic Repeats, is a natural defense mechanism found in bacteria.
- It acts as a type of immune system that helps bacteria fend off viral infections.
- Cas9, on the other hand, is an enzyme that works alongside CRISPR. It acts as a pair of "molecular scissors" that can cut DNA at specific locations.
- The CRISPR-Cas9 system has been harnessed by scientists to edit genes by targeting specific DNA sequences within an organism's genome. By designing a small piece of RNA, called a guide RNA (gRNA), that matches the target DNA sequence, scientists can direct the Cas9 enzyme to that specific location. Once the Cas9 enzyme binds to the target DNA, it cuts both strands, creating a break in the DNA sequence.
- This break triggers the cell's natural repair mechanisms, which can be exploited to introduce desired changes in the DNA. Scientists can either allow the cell to repair the break on its own, resulting in small insertions or deletions that can disrupt gene function, or they can provide a DNA template that guides the repair process, enabling the introduction of specific changes or new genetic material.
- The potential applications of CRISPR-Cas9 are vast and span various fields. In medicine, it holds promise for treating genetic disorders by correcting or modifying disease-causing mutations. It can also be used to engineer cells for immunotherapy or develop more accurate disease models for research purposes. In agriculture, CRISPR-Cas9 has the potential to enhance crop yields, improve nutritional content, and increase resistance to pests or diseases.
- While CRISPR-Cas9 offers great potential, it also raises ethical concerns and challenges. The technology's ability to make heritable changes to the human germline genome has sparked debates about the ethical implications of manipulating human traits and characteristics. The scientific community and regulatory bodies are actively working on establishing guidelines and regulations to ensure responsible use of this powerful tool.

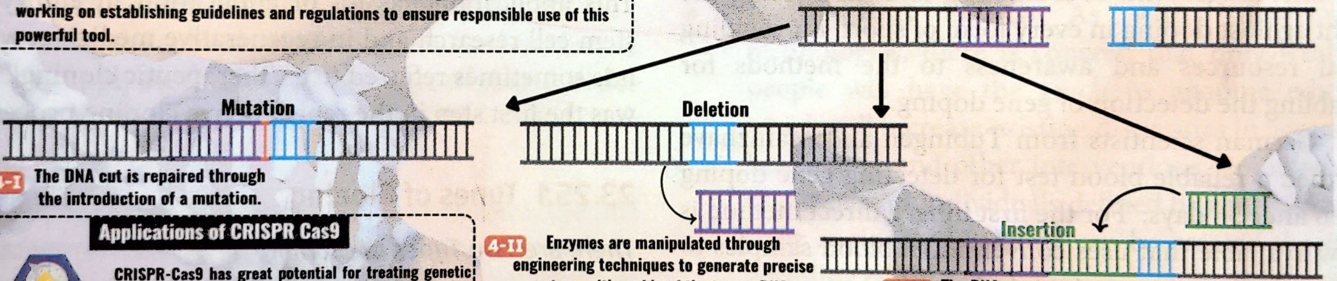


① The specific DNA sequence to be targeted is identified.

② The guide RNA, possessing a sequence that complements the target DNA sequence, forms a binding interaction with the target DNA.

③ The Cas9 enzyme utilizes a particular DNA sequence as a guide to locate the precise site where it binds to the complementary guide RNA, leading to the cleavage of both strands of the DNA.

④ Following the cleavage of the target sequence, the CRISPR system programming can lead to three possible outcomes or scenarios.



4-I The DNA cut is repaired through the introduction of a mutation.

4-II Enzymes are manipulated through engineering techniques to generate precise cuts on either side of the target DNA, enabling the excision of the target DNA and subsequent rejoining of the DNA ends.

4-III The DNA repair system can be utilized to exploit its functionality in order to insert a specific DNA segment into the genome.

Applications of CRISPR Cas9

Gene Therapy	CRISPR-Cas9 has great potential for treating genetic disorders by editing the patient's cells. It enables the correction, removal, or addition of specific genes, opening new treatment possibilities for conditions like sickle cell anemia, cystic fibrosis, and certain cancers.
Disease Modeling and Drug Discovery	CRISPR-Cas9 enables precise genetic modifications for accurate disease models, aiding the study of disease mechanisms, drug target identification, therapy development, and faster drug discovery.
Agriculture and Food Security	CRISPR-Cas9 revolutionizes agriculture by enhancing crop traits for improved yield, nutrition, and resilience. It offers a precise and efficient method to introduce desired genetic changes, addressing food security challenges and promoting sustainable agriculture.
Livestock Improvement	Cas9 enhances livestock through targeted genetic modifications, improving disease resistance, productivity, and desirable traits. This benefits animal welfare and agricultural productivity.
Conservation Biology	CRISPR-Cas9 aids conservation efforts by preserving endangered species. It can address genetic issues, increase diversity, and mitigate harmful mutations in small populations.
Biomedical Research	CRISPR-Cas9 is a valuable tool for basic research, enabling precise gene manipulation. It facilitates the study of gene functions, the role of specific genes in biological processes, and the impact of genetic variations on development, physiology, and disease progression.

Ethical Considerations of CRISPR-Cas9 Gene Editing

Off-Target Effects	Unintended modifications to non-target DNA sequences can have unknown consequences.
Germline Editing	Modifying reproductive cells raises ethical questions, including hereditary changes and potential inequalities.
Ethical Responsibility	Researchers must consider risks and benefits, promoting transparency and responsible practices.
Regulatory Framework	Guidelines and oversight are crucial to prevent misuse and ensure ethical use of CRISPR-Cas9.
Informed Consent	Comprehensive information empowers individuals to make informed decisions about gene editing interventions.
Global Collaboration	International cooperation is essential to establish shared ethical standards and address global concerns.
Public Engagement	Open discussions and education foster understanding and consider societal values in decision-making.
Long-Term Consequences	Monitoring edited organisms and their offspring is vital for assessing safety and ethical implications.

Future Perspectives of CRISPR-Cas9 Gene Editing

- Advancements in Efficiency
- Reduced Off-Target Effects
- Alternative Gene-Editing Tools
- Therapeutic Breakthroughs
- Agricultural Innovations
- Disease Modeling and Drug Discovery
- Personalized Medicine
- Ethical and Social Discussions
- Environmental Conservation
- Broadening Applications

transplants. In fact, there is less danger of organ rejection.

It is also called as 'Somatic Cell Nuclear Transfer or Research Cloning'. In this technique, the resultant embryo is allowed to grow for 14 days. Its stem cells would then develop into human tissue or a complete human organ for transplant. The first successful therapeutic cloning was performed in November 2001 by Advanced Cell Technology, a biotech company in Worcester.

Uses of Therapeutic Cloning

1. Overcomes the problem of immune rejection, which is a major concern in tissue transplantation or organ transplantation as patients' own cells are used (immunosuppressant will not be used anymore then).
2. Cells, which are removed (Pluripotent), can give rise to all cells in the body except embryo, i.e., it can treat diseases by replacing damaged cells.
3. It can help in studying of stem cells and future medical importance to treat common diseases like diabetes, heart disease and Parkinson's diseases.
4. It can help in understanding the process of ageing and ways to postpone it.
5. It can help in understanding the process of cancer formation.
6. It can help in plastic, reconstructive and cosmetic surgeries. Breast 'implant surgery' is possible through Therapeutic Cloning.

Opposing Views on Human Cloning

The Centre for Genetics and Society also presents viewpoints for both reproductive and therapeutic human cloning.

- President George W. Bush's council on Bio-ethics released its publication in July 2002 – *Human Cloning and Human Dignity*.
- The United States National Bioethics Advisory Committee on 9 June 1997 submitted its full report on cloning of human being. Several commissioned papers by various experts are included in the report and address scientific, religious, legal and ethical considerations. In October 2000, this committee was dissolved.

The main site to find articles in favour of human cloning with likes to news, commentary and discussion forums is reproductive cloning; however, the site now appears to be taken down.

Religious Perspective Different religious gurus are also against complete cloning of human beings.

(Refer **Infographic – Cloning**)

23.26 STEM CELLS

Stem cells are those having the ability to continuously divide and differentiate (develop) into various other kind(s) of cells/tissues.

Properties of Stem Cells

Stem cells differ from other kinds of cells in the body. All stem cells, no matters what their source is, show three general properties:

- These are **unspecialised cells** (blank cells).
- They have the **ability of proliferation and renewal** (These are capable of dividing and renewing themselves for long periods of time).
- **Have the potential to give rise to specialised cell types** (differentiation).

Types of Stem Cells

1. **Embryonic stem cells (ESCs)**
2. **Induced pluripotent stem cells (iPSCs)**
3. **Adult stem cells**
4. **Amniotic stem cells/ Perinatal stem cells**
5. Fetal stem cells

(Refer **Infographic – Stem Cells**)

Stem Cell Type	Description	Example
Totipotent	Each cell can develop into a new individual	Cells from early (1–3 days) embryos
Pluripotent	Cells can form any (over 200) cell types	Some cells of blastocyst / inner cell mass-ICM (5 to 14 days)
Multipotent	Cells differentiated, but can form a number of other tissues	Foetal tissue, cord blood and adult stem cells

As per their potential to differentiate into other types of cells, stem cells are of various types:

- Totipotent
- Multipotent
- Pluripotent
- Oligopotent
- Uni potent

Toti potent These types of stem cells have the ability to develop a complete organism. The fertilised egg (zygote)

CLONING

WHAT IS CLONING?

- Cloning is the process of creating an identical or genetically identical copy of an organism, cell, or DNA fragment. It involves replicating the genetic information of a specific individual or entity to produce a genetically identical clone.
- The term cloning describes a number of different processes that can be used to produce genetically identical copies of a biological entity. The copied material, which has the same genetic makeup as the original, is referred to as a clone. Researchers have cloned a wide range of biological materials, including genes, cells, tissues and even entire organisms, such as a sheep.

TYPES OF CLONING

Reproductive Cloning

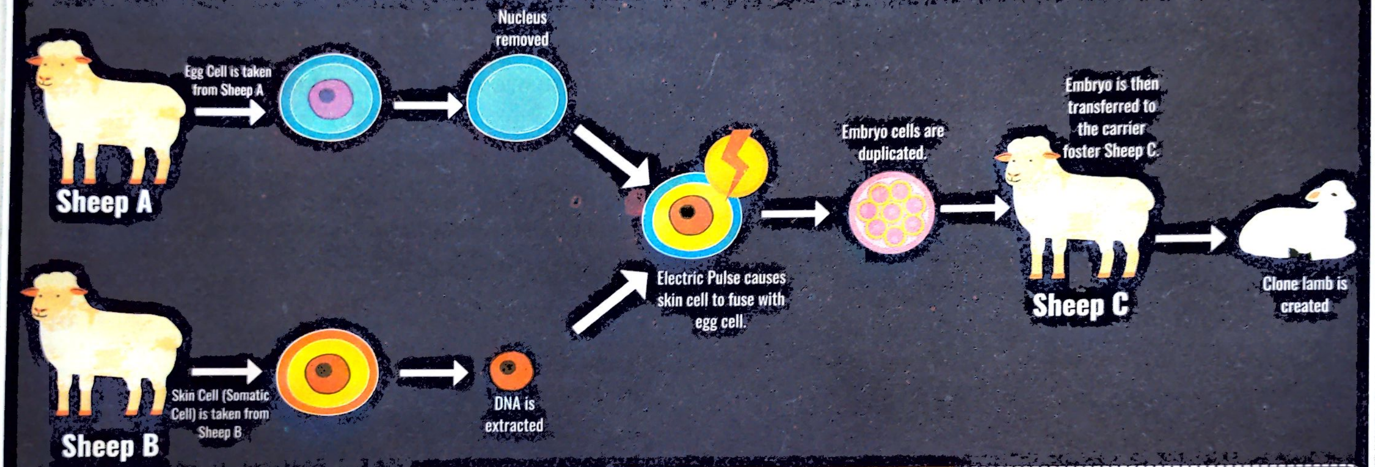
This cloning method creates an organism with the same genes as the original. It involves transferring DNA from a donor cell into an empty egg cell, which is then stimulated to grow into an embryo. The embryo is implanted into a surrogate mother, resulting in the birth of an identical individual.

Therapeutic Cloning

Therapeutic cloning, also known as somatic cell nuclear transfer (SCNT), produces embryonic stem cells for medical use. It involves transferring the nucleus of a non-reproductive cell into an egg cell with no nucleus. The developed embryo provides a source of stem cells for research or potential therapies.

Molecular/Gene Cloning

Molecular cloning is a laboratory technique used to replicate DNA fragments. It involves inserting a specific DNA sequence into a vector (such as a plasmid) and introducing it into a host organism, usually a bacterium or yeast. This allows for the replication and amplification of the DNA fragment.



Egg Cell is taken from Sheep A

Nucleus removed

Skin Cell (Somatic Cell) is taken from Sheep B

DNA is extracted

Electric Pulse causes skin cell to fuse with egg cell.

Embryo cells are duplicated.

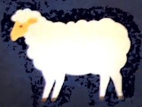
Embryo is then transferred to the carrier foster Sheep C.

Clone lamb is created

APPLICATIONS OF CLONING

Reproductive Cloning

- Dolly the Sheep: First mammal cloned from an adult somatic cell.
- Agricultural Cloning: Reproducing high-quality livestock with desirable traits.
- Conservation Efforts: Preserving endangered species by creating genetic replicas.



ENDANGERED

Therapeutic Cloning

- Stem Cell Research: Generating embryonic stem cells for regenerative medicine.
- Tissue and Organ Transplantation: Providing genetically matched cells and tissues for transplantation.
- Disease Modeling: Creating animal models to study and develop treatments for diseases.

Cellular Cloning

- Biotechnology and Drug Development: Producing recombinant proteins and therapeutic substances.
- Cloning for Research: Replicating and studying specific cell types in laboratories.

Artificial Reproduction

- Assisted Reproductive Technology (ART): Assisting couples with infertility using donor sperm or eggs for IVF.

ADVANTAGES

1. Genetic Preservation: Cloning allows for the preservation of valuable genetic traits in plants and animals.
2. Medical Advancements: Cloning techniques contribute to advancements in regenerative medicine, organ transplantation, and disease research.
3. Agricultural Benefits: Cloning helps reproduce high-quality livestock with desirable traits, enhancing food production and quality.
4. Species Conservation: Cloning can aid in the preservation of endangered species and potentially revive extinct species.

CHALLENGES

1. Low Success Rates: Cloning success rates are typically low, leading to inefficient reproduction and limited application.
2. Ethical Concerns: Cloning raises ethical dilemmas related to the manipulation and ownership of genetic material, as well as concerns about animal welfare.
3. Health Issues: Cloned organisms may experience health problems, including increased susceptibility to diseases and developmental abnormalities.
4. Public Perception: Public opinion on cloning varies, and concerns about safety, morality, and potential misuse can affect acceptance and support.

ETHICAL CONSIDERATIONS

Human Dignity

Cloning raises concerns about respecting human dignity and the value of human life.

Animal Welfare

Cloning animals raises ethical questions about the well-being and quality of life of cloned organisms.

Playing God

Cloning may be seen as infringing upon nature or religious beliefs, raising concerns about humanity's role in manipulating life.

Public Perception

Ethical concerns encompass public opinion, societal values, and responsible application of cloning technologies.

Reproductive Cloning

Ethical concerns arise due to potential risks, unknown consequences, and violations of individual autonomy when cloning humans.

Unintended Consequences

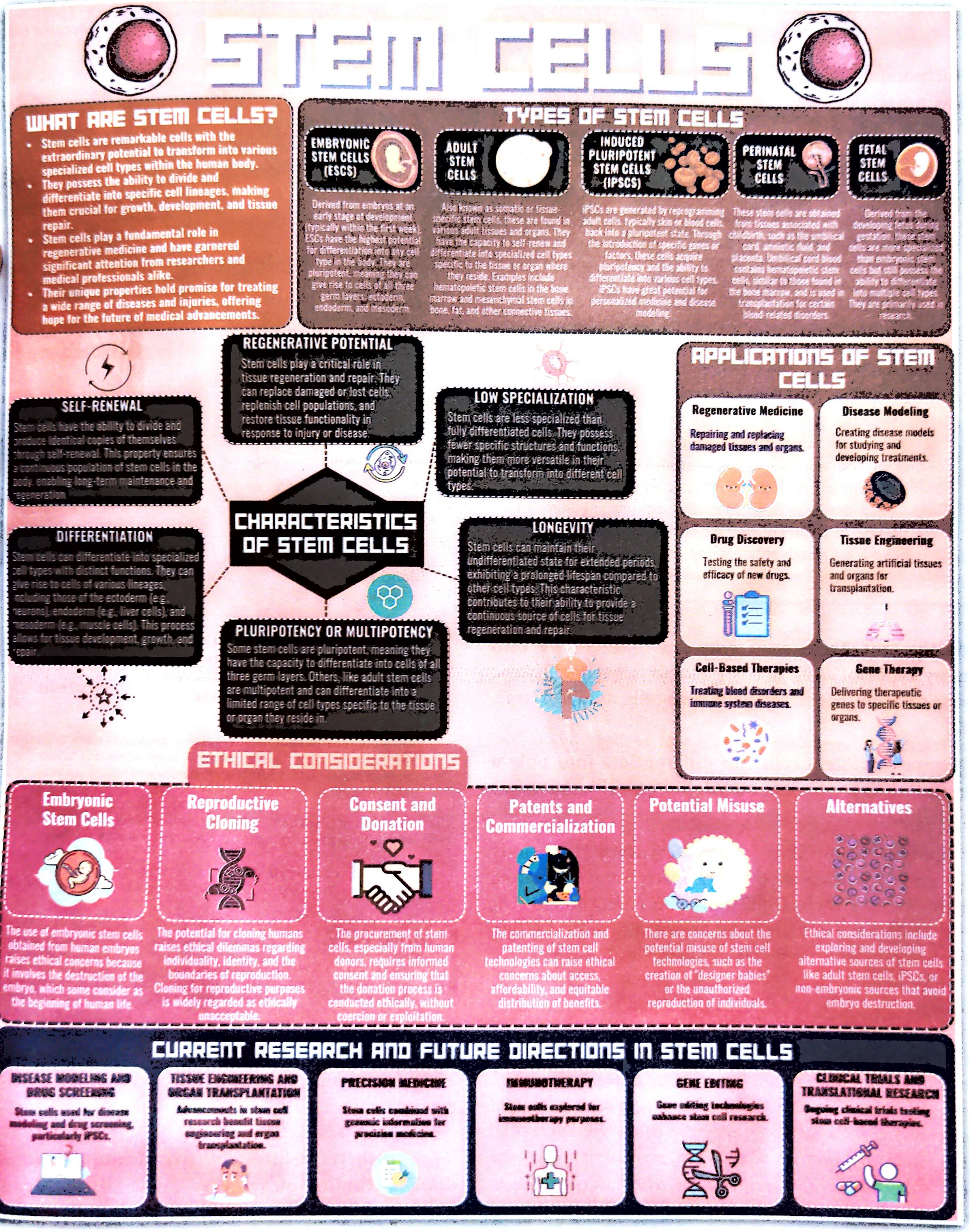
Cloning may have unforeseen short-term and long-term consequences that need careful consideration.

Consent and Autonomy

Cloning involving human subjects must ensure informed consent, respect for personal autonomy, and protection of rights.

Equality and Justice

Ethical considerations involve ensuring equal access to cloning technologies and preventing disparities and potential misuse.



STEM CELLS

WHAT ARE STEM CELLS?

- Stem cells are remarkable cells with the extraordinary potential to transform into various specialized cell types within the human body.
- They possess the ability to divide and differentiate into specific cell lineages, making them crucial for growth, development, and tissue repair.
- Stem cells play a fundamental role in regenerative medicine and have garnered significant attention from researchers and medical professionals alike.
- Their unique properties hold promise for treating a wide range of diseases and injuries, offering hope for the future of medical advancements.

TYPES OF STEM CELLS

EMBRYONIC STEM CELLS (ESCS)

Derived from embryos at an early stage of development (typically within the first week). ESCs have the highest potential for differentiation into any cell type in the body. They are pluripotent, meaning they can give rise to cells of all three germ layers: ectoderm, endoderm, and mesoderm.

ADULT STEM CELLS

Also known as somatic or tissue-specific stem cells, these are found in various adult tissues and organs. They have the capacity to self-renew and differentiate into specialized cell types specific to the tissue or organ where they reside. Examples include hematopoietic stem cells in the bone marrow and mesenchymal stem cells in bone, fat, and other connective tissues.

INDUCED PLURIPOTENT STEM CELLS (IPSCS)

iPSCs are generated by reprogramming adult cells, typically skin or blood cells, back into a pluripotent state. Through the introduction of specific genes or factors, these cells acquire pluripotency and the ability to differentiate into various cell types. iPSCs have great potential for personalized medicine and disease modeling.

PERINATAL STEM CELLS

These stem cells are obtained from tissues associated with childbirth, such as the umbilical cord, amniotic fluid, and placenta. Umbilical cord blood contains hematopoietic stem cells, similar to those found in the bone marrow, and is used in transplantation for certain blood-related disorders.

FETAL STEM CELLS

Derived from the developing fetus during gestation, these stem cells are more specialized than embryonic stem cells but still possess the ability to differentiate into multiple cell types. They are primarily used in research.

CHARACTERISTICS OF STEM CELLS

SELF-RENEWAL

Stem cells have the ability to divide and produce identical copies of themselves through self-renewal. This property ensures a continuous population of stem cells in the body, enabling long-term maintenance and regeneration.

REGENERATIVE POTENTIAL

Stem cells play a critical role in tissue regeneration and repair. They can replace damaged or lost cells, replenish cell populations, and restore tissue functionality in response to injury or disease.

LOW SPECIALIZATION

Stem cells are less specialized than fully differentiated cells. They possess fewer specific structures and functions, making them more versatile in their potential to transform into different cell types.

DIFFERENTIATION

Stem cells can differentiate into specialized cell types with distinct functions. They can give rise to cells of various lineages, including those of the ectoderm (e.g. neurons), endoderm (e.g., liver cells), and mesoderm (e.g., muscle cells). This process allows for tissue development, growth, and repair.

LONGEVITY

Stem cells can maintain their undifferentiated state for extended periods, exhibiting a prolonged lifespan compared to other cell types. This characteristic contributes to their ability to provide a continuous source of cells for tissue regeneration and repair.

PLURIPOTENCY OR MULTIPOTENCY

Some stem cells are pluripotent, meaning they have the capacity to differentiate into cells of all three germ layers. Others, like adult stem cells are multipotent and can differentiate into a limited range of cell types specific to the tissue or organ they reside in.

APPLICATIONS OF STEM CELLS

Regenerative Medicine

Repairing and replacing damaged tissues and organs.

Disease Modeling

Creating disease models for studying and developing treatments.

Drug Discovery

Testing the safety and efficacy of new drugs.

Tissue Engineering

Generating artificial tissues and organs for transplantation.

Cell-Based Therapies

Treating blood disorders and immune system diseases.

Gene Therapy

Delivering therapeutic genes to specific tissues or organs.

ETHICAL CONSIDERATIONS

Embryonic Stem Cells

The use of embryonic stem cells obtained from human embryos raises ethical concerns because it involves the destruction of the embryo, which some consider as the beginning of human life.

Reproductive Cloning

The potential for cloning humans raises ethical dilemmas regarding individuality, identity, and the boundaries of reproduction. Cloning for reproductive purposes is widely regarded as ethically unacceptable.

Consent and Donation

The procurement of stem cells, especially from human donors, requires informed consent and ensuring that the donation process is conducted ethically, without coercion or exploitation.

Patents and Commercialization

The commercialization and patenting of stem cell technologies can raise ethical concerns about access, affordability, and equitable distribution of benefits.

Potential Misuse

There are concerns about the potential misuse of stem cell technologies, such as the creation of "designer babies" or the unauthorized reproduction of individuals.

Alternatives

Ethical considerations include exploring and developing alternative sources of stem cells like adult stem cells, iPSCs, or non-embryonic sources that avoid embryo destruction.

CURRENT RESEARCH AND FUTURE DIRECTIONS IN STEM CELLS

DISEASE MODELING AND DRUG SCREENING

Stem cells used for disease modeling and drug screening, particularly iPSCs.

TISSUE ENGINEERING AND ORGAN TRANSPLANTATION

Advancements in stem cell research benefit tissue engineering and organ transplantation.

PRECISION MEDICINE

Stem cells combined with genomic information for precision medicine.

IMMUNOTHERAPY

Stem cells explored for immunotherapy purposes.

GENE EDITING

Gene editing technologies enhance stem cell research.

CLINICAL TRIALS AND TRANSLATIONAL RESEARCH

Ongoing clinical trials testing stem cell-based therapies.

and the cells produced by the first few divisions of the fertilised egg cells, all are totipotent in nature.

Pluripotent These types of stem cells **can differentiate into nearly all cells,** i.e., Blastocyst-based stem cell/ Inner cell mass (ICM).

STAGES OF EMBRYOGENESIS

Embryonic stem cell lines are derived during embryogenesis process. After fusion of sperm and egg, the zygote cell starts to divide mitotically in different embryonic stages – Marula stage (4–16 cell structure – 2 days), Blastula stage (128–256 cell structure – 5 days). This blastula/blastocyst stage at which pluripotent embryonic stem cell lines are generated. After blastocyst stage, the tissues of the embryo further grow and the cells become multipotent in nature

Derivation and Use of Embryonic Stem Cell Lines

The inner cell mass (the part that would form the foetus) of the embryo is separated and disrupted to form embryonic cell lines. In this process, embryo die. These cells are put under specific culture medium, to differentiate in different cell types. These differentiated cells have a lot of advantages: for repairing or replacing defective cells or tissues in human beings.

Multipotent These stem cells **can differentiate into many types of cells** that are closely related cells, i.e., bone marrow, haematopoietic stem cells, adipose tissue, etc.

Oligopotent Stem cells can **differentiate into only a few cells like** lymphoid or myeloid stem cells, squamous epithelium.

Unipotent These cells can **differentiate into only one cell type,** but have the property of self-renewal, distinguishing them from non-stem cells, though it is unclear if they actually exist or not, i.e., muscle stem cells.

23.26.1 Stem Cell Treatment

It is an intervention strategy type for inducing new cells into damaged tissue for treating disease or injury. The self-renewing ability for giving rise to consequent generations with variable capacities offers vital potential for generating tissues, which can possibly replace the body's diseased and damaged cells. The risk of rejection and side effects will also be minimal in this case.

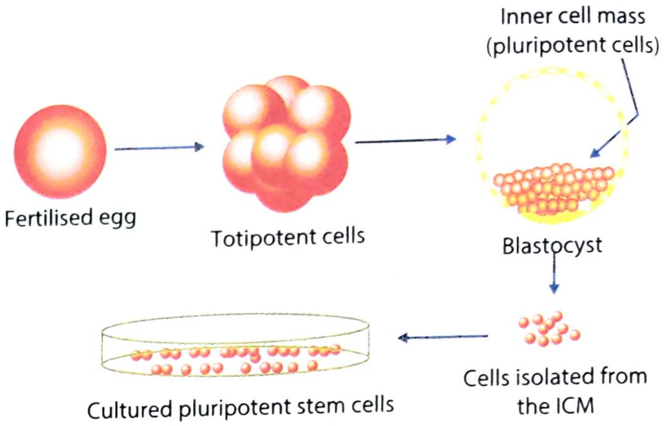
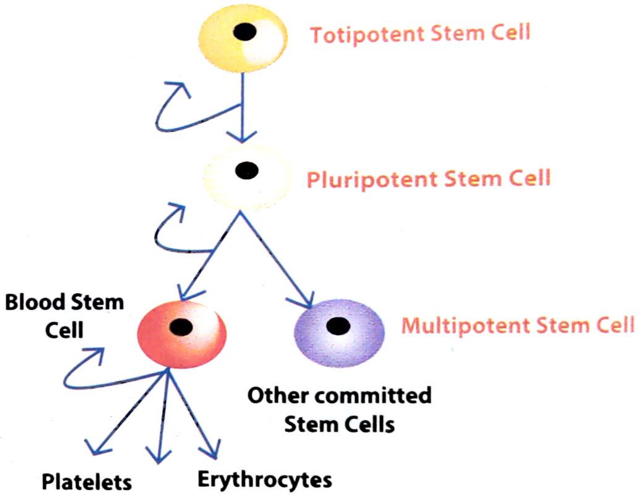


Figure 23.1
Culture of Stem Cells and Blastocyst



Totipotent Stem Cell: These cells have unlimited capability and have the capability to form extrae mbryonic membranes and tissues, the embryo itself and all postmbryonic tissues and organs. An example is an embryo.

Pluripotent Stem Cell: These cells are capable of giving rise most, but not all, tissues of an organism. An example is inner Mass Cell.

Multipotent Stem Cell: These cells are committed to give rise to the cells that have specific functions. An example is blood stem cells.

Figure 23.2
Pictorial Presentation of Totipotent, Pluripotent and Multipotent Nature of Stem Cells

Large number of stem-cell therapies are existing; however, most of them are at experimental stage or costlier, with the noteworthy exception of bone marrow transplantation. **It is anticipated that adult and embryonic stem cells will soon be able to treat cancer, Type 1 diabetes mellitus, spinal cord injury, Parkinson's disease, Huntington's disease, Celiac Disease, arthritis, leukaemia and other cancers, cardiac failure, muscle**

damage and neurological disorders, and many others. Stem cells are also used in the testing of new drugs and faster development of drug.

23.26.2 Stem Cell Controversy

This controversy is over ethical debate due to killing of human embryos in embryonic stem cells. This is not in all other different nature of stem cell those involves in the creation, usage and destruction of human embryos. For example, adult stem cells, amniotic stem cells and induced pluripotent stem cells have no issue because using or destroying of human embryos is very rare.

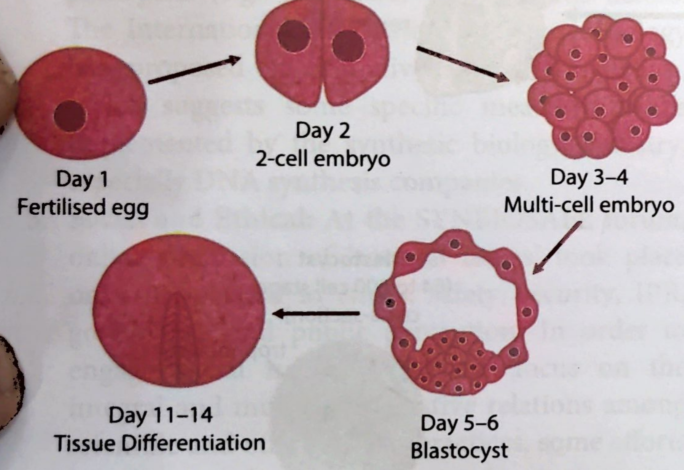


Figure 23.3
Stages of Embryogenesis

23.26.3 India's Top Centres for Stem Cell Research

- Institute for Stem Cell Biology and Regenerative Medicine, Bengaluru
- Centre for Stem Cell Research (CSCR), Christian Medical College (CMC) Vellore, Tamil Nadu
- School for Regenerative Medicine, Manipal, Karnataka
- Centre for Stem Cell Science, Hyderabad
- International Centre for Stem Cell, Cancer and Bio-technology, Pune
- National Centre for Cell Science, Pune
- L.V. Prasad Eye Institute, Hyderabad

DRAFT GUIDELINES FOR STEM CELL RESEARCH

Indian Council of Medical Research (ICMR) and Department of Biotechnology in 2019 released revised guidelines on stem cell research 2017. **All stem cell research will evolve in an ethical and scientifically responsible manner.** These guidelines have also provision of various stakeholders in research related to human stem cells and have also options for sharing IPRs information. All guidelines will ensure through National Apex Committee for stem cell research and therapy. This committee currently monitors and oversees stem cell research activities in India.

(Refer **Infographic – Stem Cell**)

23.27 EPIGENETICS

Concept of epigenetics was given by **Conrad Waddington** in 1942 as 'the branch of biology'. He has done his work to study the interactions between genes and their expression, those are **responsible for phenotypic expression.** It has emerged to bridge the gap between nature and nurture. In the 21st century, the 'the study of heritable changes in genome function that occur without a change in DNA sequence' is the most acceptable definition of this branch.

23.28 SYNTHETIC BIOLOGY AND SYNTHETIC LIFE

Synthetic biology is not only considered to design and fabricate biological components and systems, which are not already existing in the natural world but also re-design and fabricate existing biological systems.

The term 'synthetic biology' was first used on genetically engineered bacteria, created with recombinant DNA technology. Later, the term 'synthetic biology' was used as a means to **redesign life.**

Diagnostic tools for diseases such as HIV and hepatitis viruses as well as devices from bio molecular parts with interesting functions have been produced by synthetic biology, which count as its major achievements so far. More trials are being made to assemble unnatural components that can support Darwinian evolution.

Significance

- It provides a complementary perspective to consider, analyse and ultimately understand the living world.

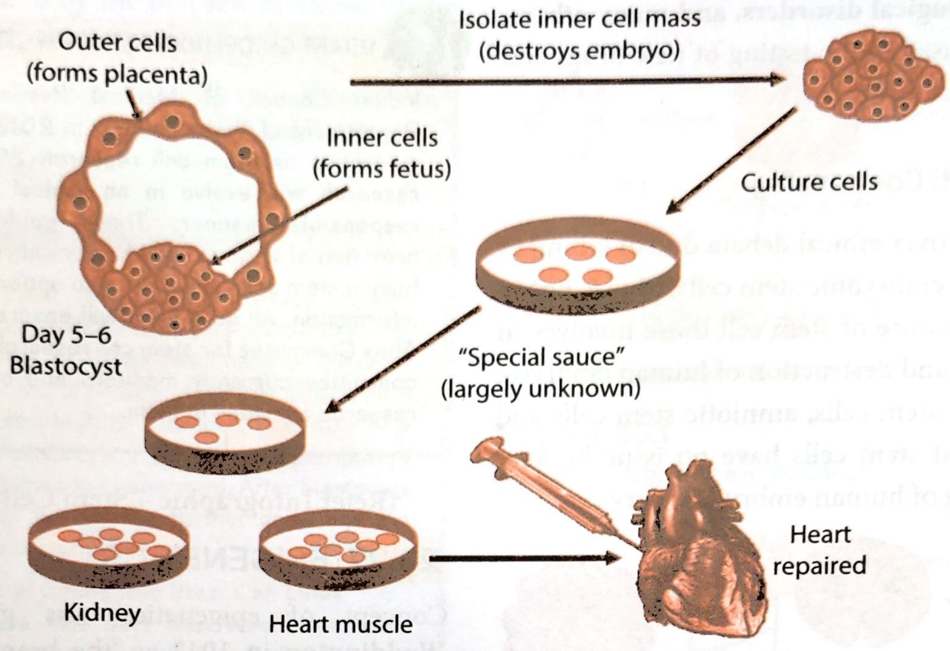

Outer cells
(forms placenta)
Inner cells
(forms fetus)
Day 5–6
Blastocyst
Isolate inner cell mass
(destroys embryo)
Culture cells
"Special sauce"
(largely unknown)
Heart
repaired
Kidney
Heart muscle

Figure 23.4
Derivation and Use of Embryonic Stem Cell Lines

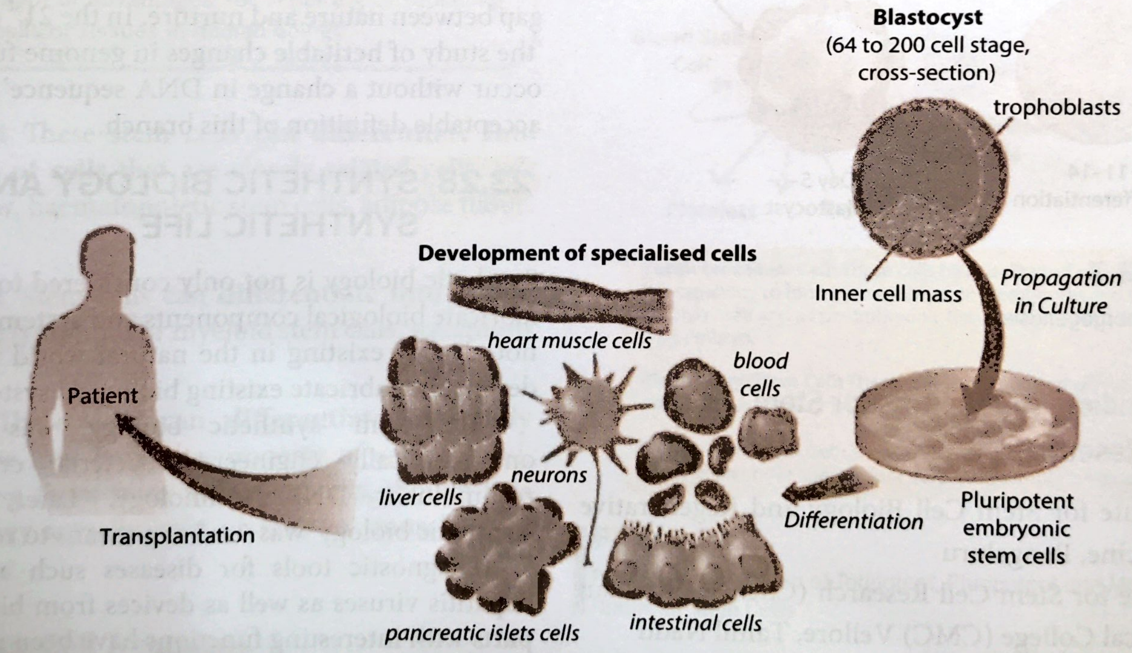

Blastocyst
(64 to 200 cell stage,
cross-section)
trophoblasts
Inner cell mass
Propagation
in Culture
Pluripotent
embryonic
stem cells
Differentiation
Development of specialised cells
heart muscle cells
blood
cells
neurons
liver cells
intestinal cells
pancreatic islets cells
Patient
Transplantation

Figure 23.5
Stem Cell Treatment

- It also attracts physicist, chemists and others, being an approach with which probing the behaviour of molecules and their activity inside living cells becomes easy.

Challenges

1. **Opposition to Synthetic Biology:** Civil society groups oppose Synthetic Biology and have called

for a global moratorium on developments in the field and for no synthetic organisms to be released from the lab. Taking into view the societal impacts of synthetic biology, they dub it as 'Extreme Genetic Engineering'.

2. **Safety and Security:** Besides numerous scientific and technical challenges, questions raised on synthetic biology are for bio-security, bio-safety, involvement of stakeholders and intellectual property rights. For instance, if on one hand, the study of synthetic biology may lead to more efficient ways to produce medical treatments (e.g., against malaria), on the other hand, it may also lead to synthesis or redesign of harmful pathogens (e.g., smallpox) by malicious actors. The International Association Synthetic Biology has proposed an initiative for self-regulation, which suggests some specific measures to be implemented by the synthetic biology industry, especially DNA synthesis companies.
3. **Social and Ethical:** At the SYNBIOSAFE forum, online discussion of 'societal issues' took place on issues related to ethics, safety, security, IPR, governance and public perception. In order to engage social issues, 'upstream' focus on the integral and mutually formative relations among scientific and other human practices, some efforts have been made. Such efforts render an attempt to invent ongoing and regular forms of collaboration among synthetic biologists, ethicists, political analysts, funders, human scientists and civil society activists.

Synthetic Life

Synthetic life is **artificial life created from nonliving (abiotic) substances. It is artificial life created in vitro from bio-chemicals and their component materials.** It belongs to the discipline of synthetic biology. It is usually distinguished from mechanical life that usually belongs to the discipline of robotics. For synthetic life to be life, it must have the properties of self-replication (able to make copies of itself through cell division), and it must be capable of self-perpetuation, it must function autonomously, just as a normal life form would.

However, creating synthetic life is a great challenge and a complex task. **It entails the creation of an artificial genetic code and an artificial DNA.** It would also involve creating cellular organelles such as mitochondria, ribosome and nucleus, completely anew. Creating a fully synthetic cell would also be expensive. These constraints can be bypassed and a new organism can be created by just replacing the genome in an existing, natural cell with a different genome created by gene synthesis. This is one way around. The creation of Synthia, in 2010, marked the first instance of achieving it.

PART – (C) BIOLOGICAL TERMINOLOGY

23.29 BIOLOGICAL TERMINOLOGY

23.29.1 Biosensor

It is an analytical device, comprising a biological component and a physicochemical detector component, which is used for the detection of an analyte.

In this process, a **sensitive biological element** is used (tissue, microorganisms, organelles, cell receptors, enzymes, antibodies, nucleic acids, etc.) under the **transducer or the detector (it is an electronic or signal processor)** and appears in the form of certain signals for detection.

Features of a Biosensor

- Small size that should be appropriate for use
- Cheap and producible in large quantity
- Rapid result
- Economical
- Blood glucose biosensor is an example of commercial biosensor. It breaks the blood glucose down by using the enzyme glucose oxidase
- Industry – process monitoring and control, particularly food and drink
- Medicine – diagnostics, metabolites, hormones
- Military – battlefield monitoring of poison gases, nerve agents and people
- Domestic – home monitoring of non-acute conditions

Some examples are

- Sugar monitoring in diabetic people
- Used to solve environmental problems like detection of pesticides
- Remote sensing of airborne bacteria in counter-bioterrorist activities
- Pathogens detection

- Determining of intensity of toxic substances before and after bioremediation
- Presence of organophosphates
- Detection of toxic metabolites such as mycotoxins
- Pregnancy test (Prega news, etc.)

23.29.2 Biochip

Biochip was developed in 1983 for the monitoring of fisheries. It is an outcome of the field of computer science, electronics and biology.

- It is a bio-security device for exact tracking of information.
- A single electronic card may replace everything in the wallet including, cash, credit cards, ATM card, ID cards, insurance, medical records.
- It is a microchip of a computer, used for identification purposes.
- It is a radio frequency identification (RFID) system and works on low-frequency radio signals for the communication between the bio-chip and the reader. It is inserted under the skin for tracking purpose.

Applications

1. A person/animal can be tracked anywhere in the world.
2. Stores and updates data of financial, medical, demographics of a person.
3. Used as secured e-commerce systems.
4. Medicinal implementations (used as glucose detector, Biochip as oxygen sensor, used as blood pressure sensor).

The development of this technique is a major push of the rapidly growing biotechnology industry, which encompasses a wide range of research, which includes genomics, proteomics, and pharmaceuticals, etc. Genomics is a branch of genetics dealing with the study of genomes of organisms.

23.29.3 Bio Signature

Any substance such as an element, isotope, molecule or phenomenon providing scientific proof of past or present life is known as a bio-signature. Some related branches such as geo-chemistry, geo-biology, and geo-microbiology frequently use bio-signatures to determine the presence of living organisms in a sample.

Bio-signatures, which are produced from life process are nucleic acids, lipids, proteins, amino acids, kerogen-like material and different morphological features. Microbes that participate in the geochemical processes leave some features in the rock record, indicative as bio-signatures. A potential bio-signature is a phenomenon which can be produced from living sources, but it can also be originated from abiotic sources.

For example, the types of bacteria and archaea living in particular environment can be detected by measuring a sample of fatty acids. The long-chain fatty alcohols, which consist of more than 23 atoms are produced by planktonic bacteria. Geochemists used the term biomarker for such types of indications.

Atmosphere

Over the past many years, a fog of chemicals were created in the process of life, similar to the one in an ordinary chemical equilibrium. For instance, life on Earth generates a large amount of oxygen and small amount of methane. According to some scientists, life on Mars could be detected by measuring the ratio of hydrogen and methane levels on the planet, as the presence of methane in the atmosphere, gives a hint that there must be an active source on the planet, because it is an unstable gas.

23.29.4 Bio Generics

Bio generics are the biological drugs made from living organisms and are usually used to treat serious diseases such as cancer, HIV and AIDS and Alzheimer's disease, etc.

These drugs are normally very expensive to produce and purchase because they are derived from the living organisms. In India, bio generics is a booming sector with a very high growth rate. Domestic companies are manufacturing recombinant insulin, monoclonal antibody (MAb) products, interferon alpha, erythropoietin and various types of recombinant vaccines. All the Western-made bio-pharma products are very highly priced, which make them unaffordable to most of the world. Some of the Western-made bio-pharma products will nearly lose their patent protections and India wants to grasp this opportunity. Consequently, the government has streamlined its few drug application and also reviewed some procedures, further providing strong tax incentive to the Indian

Biotech Industry. Now, industries are heavily investing in the development of facilities. Very soon, Indian bio generics makers are expected to obtain their first approval for manufacturing products for the European market.

Various Indian companies like Dr Reddy's, MJ Biopharma, Biocon, Intas Pharmaceuticals, etc., have the capability to build and produce recombinant biotech products such as Hepatitis B vaccine, streptokinase, human insulin, interferon and MAbs (Monoclonal Antibodies) for cancer and other diseases.

3.29.5 Bio Computer

A Bio computer is a biologically derived molecular (e.g., DNA and proteins) system for computational calculations. These calculations are storing, retrieving and processing of various data. A pathway or series of metabolic pathways, which involve biological materials that are engineered to perform in a certain manner based upon the conditions (input) of the system, all come under bio computer. An output is constituted by the resulting pathway of reactions taking place, based on the engineering design of the bio computer. It can also be interpreted as a type of computational analysis.

Nano biotechnology provides the means to synthesise the multiple chemical components essential for creation of such a system. The sequence of amino acids – the chemical building blocks of proteins – dictates the chemical nature of the proteins and a specific sequence of DNA nucleotides – the building blocks of DNA molecules – in turn, dictate these sequences. Also, the synthetically designed DNA molecules themselves may function in a particular bio computer system. Thus, implementing Nano biotechnology to design and produce synthetically designed proteins and the design and synthesis of artificial DNA molecules can enable the construction of functional bio computers, e.g., Computational Genes.

Researchers in Nano-medicine hope to build molecular-scale computing devices that could be embedded in our bodies to monitor health and treat various diseases before its progress. This computer is made up of biological materials, so it has the ability to speak about biochemical feature of life.

Economics

Bio computers can be highly efficient and relatively inexpensive because all of the necessary proteins can be synthesised inside a biological cell from a single DNA molecule, which could itself be replicated many times over. We can produce bio computers in large quantities from cultures, without any machinery assemblage.

Advance Level of Bio Computer Technology

Currently, there is existence of bio computers with various functional capabilities, including logic operation and mathematical calculations. The first suggestion of a biochemical computing scheme was given by **Tom Knight** of the MIT Artificial Intelligence Laboratory. As per him, protein concentrations will work as binary signals and will perform logical operations. With the help of this method, logical operations can be performed by Bio computers. Hence, in other words, the appropriate binary output serves as a logically derived conclusion from a set of initial conditions, serving as premises from which the logical conclusion can be derived. Apart from these logical operations, bio computers can also be used for the demonstration of mathematical computations.

23.29.6 Bioplastic or Biopolymer (Biodegradable Plastic)

Bioplastics are composed of chemical compounds, which are synthesised from microbes such as bacteria or by genetically modified plants. Conventional plastics are produced from petroleum products but bioplastics are formed from renewable resources and are biodegradable.

In 1926, with a bacteria *Bacillus megaterium,* the first known bioplastic, **Polyhydroxybutyrate** (PHB) was developed. The petroleum crisis of the mid-1970s drew attention towards finding alternate options to petroleum-based products. It gave rise to molecular genetics and recombinant DNA technology.

Various renewable and non-renewable sources are used as feedstock sources for modern plastic materials. Non-renewable sources produced petroleum-based plastics and are unbreakable by glass or carbon. Renewable resources include microbial-grown and starch-extracted polymers. These materials can be strengthening with the help of natural fibres like flax, jute, hemp and other cellulose.

Polyhydroxyalkanoate (PHA) and **Poly Lactic Acid** (PLA) are also bioplastics. Starch-based fermentation produces lactic acid by bacterial activity. Polymer of lactic acid is a type of bioplastic, i.e., PLA.

Although biodegradable plastics are scientifically sound, they required a better infrastructure to expand for commercial use. For the further growth of biopolymer, there is a need to change the current view of the society by making them realising their environmental responsibility.

23.29.7 Biological Weapons and Bioterrorism

Biological weapons are artificially manufactured toxic substances, which are produced from pathogenic organisms. They are intentionally used to disrupt a host's biological process. The main aim of these biological weapons is to kill or injure the host. The major targets of these weapons are living organisms such as humans, animals or vegetation. They also have the capacity of contaminating the non-living substances such as air, water and soil.

Some characteristics, which are considered before choosing an agent as a biological weapon are high toxicity, easy availability, cheap, easy transferability from one person to another, easy dispersion in aerosol form, and have no existing vaccine. It is difficult to find a dispersing medium for biological weapon; it can be done through aerosol, but this can be clogged while spraying. Dispersal through air is also difficult as it can be washed through rain or become ineffective when came in contact with UV rays. It can also be distributed by attaching it with explosive bombs, but with this method, microbes might probably explode as well.

Bioterrorism and Biological Warfare Agents

Bioterrorism is considered as a criminal act against any unsuspecting civilians, which uses pathogenic biological agent, e.g., biological warfare agents. These biological warfare agents are generally colourless, odourless microorganisms (bacteria, viruses, fungi) or toxins, which are derived from microorganisms. It can disperse in air as aerosols or in edible items to infect mass population. They cannot be detected easily even after their release. Such attacks cause chaos and panic within a civilian population and terrorists can easily escape. The main purpose of these terrorists is to overwhelm emergency medical departments at local levels.

23.29.8 Bioleaching

In the process of bioleaching, bacterial microorganisms are administered to extract precious metals, such as gold, from ore, in which it is embedded. The bacteria feed on nutrients in minerals, and separate the metal, which can be collected in a solution. It is a very eco-friendly method to extract the metals. Even if the concentration of the metal is very low and difficult to extract through smelting or roasting, bioleaching can easily extract the metals. Microorganisms act as a catalyst to speed up natural processes inside ore. Through oxidation (a chemical process), bacteria turn metal sulphide crystals into sulphates and pure metals.

TABLE 23.1 List of biological organisms that may potentially be used as biological weapons

Microbe	Natural Environment	Target Host	Mode of Contact	Diseases/Symptoms
Bacillus anthracis (Anthrax)	Soil	Humans, domestic animals	Open wounds, inhalation	Pulmonary anthrax septicemia, flu-like symptoms
Protein Toxin (RICIN)	Extracted from castor bean plants	Humans	Contaminated food or water, inhalation, injection	Severe abdominal pain, watery and bloody diarrhoea, vomiting, weakness, fever, cough, and pulmonary oedema
Clostridium botulinum (Botulism)	Soil	Humans	Contaminated food or water	Food poisoning
Smallpox (Varicella)	Eradicated from nature, now obtained from laboratory stockpiles	Humans	Direct contact with bodily fluids or contaminated objects, inhalation	Persistent fever, vomiting, rash on tongue and in mouth, rash and bumps on skin
Clostridium perfringens	Intestines of humans and other animals, soil	Humans, domestic animals	Open wounds	Gas gangrene, severe abdominal cramps, diarrhoea

Advantages of Bioleaching

- **Economical:** Bioleaching is simple, cheaper and easy to operate and need few specialists for operating complex chemical plants. This technique is more profitable, due to the fact that necessary curbing of sulphur dioxide emissions at the time of smelting are costly.
- **Environmental:** As compared to the conventional extraction methods, it is more eco-friendly. For the company, there is occurrence of little damage to countryside due to the natural growth of bacteria; hence, the area around the mine and surrounding can be left without contamination. Bacteria are easily cultivated and recycle because they reproduce in the conditions of the mine.
- **Ore concentration:** Bioleaching is useful in extracting metals from ores that have poor concentration of metal. It also replaces the extensive crushing and grinding process that make the process cost efficient and also reduce energy consumption.

Disadvantages of Bioleaching

- **Economical:** It is a very slow process in comparison to smelting, thereby making it lesser profitable as well as the cash-flow delay.
- **Environmental:** Occasionally, the process produces toxic chemicals. Sulphuric acid and H^+ ions, so formed, can escape into the ground, thereby making the surface water acidic, causing damage to the environment. During acid mine drainage, heavy ions such as iron, zinc and arsenic are also leaked and cause 'Yellow Boy' pollution, when the pH of this solution rises.
- For metals such as copper, bioleaching is not always economically viable or fast enough, even with its low cost.

23.29.9 Biomarker

A biomarker is a naturally occurring substance, molecule, gene, etc., which is used as an indicator of a biological state, such as biological processes, pathogenic processes, or pharmacologic responses to a therapeutic intervention. It is used as a constructive tool in various scientific fields, which are of specific interest in the study of dose optimisation.

Applications

In medicine: A biomarker can be a substance that is transferred into an organism to observe the function of the organ or other aspects of health; e.g., in the evaluation of heart muscle perfusion, a radioactive isotope, rubidium chloride is used.

The detection of a particular substance in a body points towards a specific state of disease, like the presence of an antibody points towards an infection. By observing the change in the protein expression, scientists can correlate the severity off a disease and according to the progress, give treatment. Another application of biomarker is to indicate the presence of various environmental substances in epidemiology and toxicology.

In cell biology, a molecule acts as a biomarker for the detection and isolation of a particular cell type; for example, **to identify embryonic stem cells, the protein Oct-4 is used as a biomarker.** In genetics, a DNA sequence is identified as a genetic marker that causes disease or is associated with susceptibility to disease.

23.29.10 Bioinformatics

Bioinformatics is an inter-disciplinary approach, which includes application of computer science and information technology within the field of molecular biology. The term was given by **Pauline Hogeweg** in 1979. It is the development of databases, algorithms, computational and statistical observations for solving formal and practical problems that are faced during the managing and analysis of biological data. It is a mathematical and computing approach used to understand biological processes.

Commonly, bioinformatics process consists of the study and mapping of DNA and protein sequences, various DNA and protein sequences alignment for comparative study and screening and formation of 3D models of protein structures. The Human Genome Project has increased importance of Bioinformatics. The research will help develop and succeed in sequence alignment, prediction of protein structure, gene expression and protein – protein interaction, genome-wise relationship studies and other areas.

TRANSCRIPTOME

A gene is a specific DNA base-pair sequence. During a character (protein) synthesis, it transcribed into RNA (i.e., transcription) and then translates into protein synthesis (i.e., translation).

There are three types of RNA – messenger RNA (mRNA), transfer RNA (tRNA) and ribosomal RNA (rRNA). All RNAs play a significant role in producing proteins within the cytoplasm. At the time of this process, some DNA can be transformed into other types of RNA that are not coded protein but still may influence cell structure and regulating genes.

Analysis of the entire collection of RNA sequences in a cell is called transcriptome. Transcriptome is also an integral part of bioinformatics. Scientist can determine on and off of a gene to know its expression in living beings. Even in human beings, every cell has the same gene but expression in different cell varies. By the study of transcriptome, we can understand various normal and abnormal characters in human beings that can also reflect or contribute in any disease. Transcriptome data gives researchers a good place to start searching for a newly found gene's function.

National Human Genome Research Institute (NHGRI) in India has participated in two transcriptome-based projects that created various resources for researchers around the world:

1. Mammalian Gene Collection initiative
2. Mouse Transcriptome Project

The Mammalian Gene Collection initiative will setup a free, public library of human, mouse and rat mRNA sequences.

Bioinformatics differs significantly from biological computation and computational biology. Bio-engineering and biology is used by biological computation to build biological computers. On the other hand, bioinformatics uses computation to understand biology in a better manner. Bioinformatics undertakes the organising and analysing of basic biological data, whereas computational biology produces theoretical biological systems models.

Applications

1. Storage of DNA sequences.
2. It helps track evolution of organisms by measuring changes in DNA.
3. Through sequence analysis, we are obtaining enough sequence data to map genes of complex diseases such as diabetes, infertility or Alzheimer's disease.
4. Helps in analysis of mutation in cancer.
5. Expression of genes determined by measuring mRNA levels.

23.29.11 Biosparging

Biosparging is a technology for fighting ground water pollution by using naturally occurring **microorganisms to biodegrade pollutants in soil layers above groundwater aquifers.** Biosparging is a groundwater remediation technique. Groundwater remediation enables extraction in which groundwater pollution is to be filtered. Contaminants found in groundwater cover the entire variety of physical, inorganic and organic chemical, bacteriological and radioactive parameters.

In biosparging, air and nutrients are inserted into the soil layers for increasing the biological action of the naturally occurring microorganisms. These microorganisms digest the pollutants as food and hence decrease their concentrations. Its usage is undertaken for reducing the concentrations of petroleum components, which dispersed in groundwater and the layers of soil.

However, it was recently discovered that the microorganisms used in biosparging can suffer from the high temperature caused by their own metabolic activities. This can slow down the cleanup of the groundwater and even lead to continuation of the spread of contamination. It has sparked a rethink on the way groundwater remediation systems are designed.

PART A: CONVENTIONAL DISEASES

24.1 HEALTH, DISEASES AND SYMPTOMS

Health denotes the state of complete physical, mental as well as social well-being. It is not only related to the physical and mental state of an organism but is closely linked to its environment and social well-being as well.

Disease refers to the condition when the proper functions of any plant, animal or human are disturbed and weakened. It is not simply because of the physical injuries and is generally expressed in the form of symptoms.

4.2 DIFFERENT TYPES OF TERMINOLOGY USED ON THE BASIS OF NATURE OF DISEASES

Epidemic disease is the disease that affects a community with a large number of people in it, for a given period of time.

Endemic disease is the disease that affects the same area or region regularly; it is fixed to particular area.

Acute disease is a quick, short-time course disease.

Chronic disease is a disease, which is slower, gradual and lasts for a longer course or duration.

24.3 CONGENITAL VERSUS ACQUIRED DISEASES

Congenital diseases are innate diseases; these diseases are present from birth, which occur due to genetic variations. For example: colour blindness, etc.

Acquired diseases are post-featly, develop after birth.

24.4 COMMUNICABLE VERSUS NON-COMMUNICABLE DISEASES

Communicable diseases (Infectious) are transmissible by direct contact or indirect means with infected individuals or their discharge (by vector).

Non-communicable diseases (Non-infectious) are non-contagious and non-transmissible among peoples. These include organ or tissue malfunction.

24.5 ANTIGENS VERSUS ANTIBODIES

Antigens

1. They represent large molecules of proteins or polysaccharides. In rare cases, lipids or nucleic acids can also act as antigens. Certain parts of microorganisms, others persons or animal tissues also constitute some of the antigens.
2. They are present on cell surface and lead to antibodies formation, specifically reacting with them. Antigenicity of large molecules depends upon the presence of 'Epitopes', on the surface.
3. **Haptens:** They are non-proteinaceous, acting as antigens; however, they do not induce antibody production.
4. MHC (Major Histocompatibility Complex) denotes a set of protein cell surface markers present on plasma membrane. The immune system uses it to identify 'self'. The antigen represents any substance that stimulates the immune system of the body.

Antibodies

They are protein molecules called immunoglobulins (Ig) produced by lymphocytes. It is a molecule that specifically inactivates an antigen. Five major types of immunoglobulins (Igs) are: IgM, IgG, IgD, IgE and IgA, based on five types of heavy chains.

24.6 FEVER

A fever, also called as a high fever or a high temperature, is not by itself an illness, but usually a symptom of an underlying condition, most often an infection.

A fever represents an inflammatory response that usually extends beyond the infection site and affects the entire body, leading to overall increase in body temperature. Usually, the inflammation of blood cells contributes to fever. The body temperature is normally regulated as well as maintained by the hypothalamus, that is an anatomical section of brain, functioning to maintain the homeostasis in the body.

Numerous conditions that can trigger fever include:

- Infections, that include the flu, pneumonia and common cold, and

- Some immunisations, like diphtheria or tetanus (in children)
- Teething (in infants)
- Certain inflammatory diseases, that include rheumatoid arthritis and Crohn's disease
- Blood clots
- Extreme sunburn
- Food poisoning
- Some medications, that include antibiotics

24.7 COMMUNICABLE DISEASES

In these kinds of diseases, pathogens play the main role in transmitting diseases. So discussion on all pathogens is deemed necessary, for better understanding, pathogens are grouped as bacterial, viral, protozoan, helminthes, etc.

24.7.1 Bacterial Diseases

24.7.1.1 Cholera

It is a highly communicable acute diarrheal disease caused by *Vibrio cholera,* through faecal–oral route by houseflies and it is treated by health education, proper sanitation of environment and water, drugs like tetracycline and chloramphenicol.

24.7.1.2 Pneumonia

Serious and inflammatory disease of lungs caused by *Streptococcus pneumonia* and *H. influenze,* characterised by rapid shallow breathing, chest pain and fever, cough. Important drugs for pneumonia are Penicillin, Streptomycin and Ampicillin.

Pneumococcal 13-valent Conjugate Vaccine (PCV)

- The government has launched a nationwide expansion of **Pneumococcal 13-valent Conjugate Vaccine** (PCV) under the **Universal Immunisation Programme** (UIP) as a part of **'Azadi ka Amrit Mahotsav'.**
- It was for the first time in the country that PCV would be available for universal use.
- **PCV13** protects against 13 types of bacteria that cause pneumococcal disease.

24.7.1.3 Typhoid

It is an acute enteric disease caused by *Salmonella typhi,* contracted through feco–oral route, which is found in the intestine of humans. Main symptoms are high fever, stool, body ache, etc. Antibiotics for typhoid are ampicillin and chloramphenicol.

24.7.1.4 Leprosy

It is also known as Hansen's disease and is caused by *Mycobacterium leprae,* which lives in the endothelial cells of RBC, affecting peripheral nerves and skin lesions and is also a chronic disease. Multi-Drug Therapy (MDT) is used for treating leprosy.

24.7.1.5 Tetanus

Serious bacterial diseases are caused by *Clostridium tetani,* which lives in intestine of horse, and is acquired through contaminated soil or wound. Main symptoms are lockjaw, muscle stiffness, rigidity, fever, etc.

PNEUMOCOCCAL CONJUGATE VACCINES

Pneumococcal is a bacterial disease, which infects lungs, blood and brain. Mostly it causes health issue to children of less than 5 years of age. Mostly risk of this disease is for 2-year-old children and old age people who are more than 65 years old. Those people have certain medical conditions and smokers are more susceptible to this disease. These diseases also include pneumonia, meningitis, sepsis, blood infection and ear infection. **Pneumococcal Conjugate Vaccine (PCV 13)** protects against 13 types of pneumococcal bacteria, whereas **Pneumococcal Polysaccharide Vaccine (PPSV 23)** protect against 23 types.

The growing resistance of *S. pneumonia* to commonly used antibiotics underlines the need for vaccines to be used to control the Pneumococcal disease. Antibiotic resistance happens when germs like bacteria and fungi develop the ability to defeat the drugs designed to kill them. The dependence on antibiotics that are not effective against drug-resistant bacteria can be reduced.

Most people who get a pneumococcal vaccine do not have any serious problems with it. These are usually mild and go away on their own within a few days, but serious reactions are possible.

24.7.1.6 Plague (Black Death Disease)

It is caused by *Yersiniapestis* (endoparasite of rat flea) and transmitted by fleas. Plague is primarily a disease of rats. It is of three types: (i) bubonic plague, (ii) pneumonic plague, (iii) septicemic plague.

1. **Bubonic plague** is the most common type caused when an infected rodent or flea bites. It is characterised by high fever, weakness and enlargement of lymph nodes.
2. **Pneumonic plague** is most lethal form and affects lungs.
3. **Septicemic plague** a life-threatening infection of the blood.

24.7.1.7 Tuberculosis (TB)

Mycobacterium tuberculosis causes this disease, affecting the lungs and causing pulmonary TB, but it also can affect any body parts. It is a chronic disease. TB affects animals also and it is transmitted through air by droplets, sputum. TB can be diagnosed based on radiological (-ray), biochemical (Montoux, PCR, etc.) and clinical signs, symptoms like cough with sputum, evening temperature, etc. TB can be treated by DOTS therapy in DOTS centre in RNTCP.

National Tuberculosis Control Programme (NTCP) since 1962 has been operating in the country. This did not bring good results. So, it was reviewed in 1992 by an expert committee and accordingly, the Revised National TB Control Programme (RNTCP 1), which is the Indian version or application of WHO's Directly Observed Treatment Short course (DOTS), was launched on 26 March 1997 and RNTCP II (2006).

24.7.1.8 Pertussis/Whooping Cough

Pertussis is a disease of childhood and is caused by *Bordetella pertussis.* It affects respiratory passage with the characteristic 'whoop' (loud crowing inspiration) and fever. Whooping cough is spread through droplet infection and direct contact. Vaccine for pertussis is DPT for newborns.

24.7.1.9 Diphtheria

It is caused by *Corneybacterium diphtheria* and antibiotics used are penicillin, erythromycin.

24.7.1.10 Anthrax

It is caused by spore-forming *Bacillus anthracis.*

Symptoms

1. **Cutaneous:** Itchy bump, which develops into painless necrotic ulcer.
2. **Inhalation:** Severe respiration problems and shock. It is dangerous.
3. **Intestinal:** Loss of appetite, nausea, fever, severe diarrhoea, abdominal pain, vomiting.

TABLE 24.1 Some diseases and their confirmatory immunological tests

S. No.	Test	Disease
1.	Ames test	Carcinogenicity
2.	Dick test	Scarlet fever
3.	Mantoux test	Tuberculosis
4.	Rose-Waaler test	Rheumatoid fever
5.	Schick test	Diphtheria
6.	Wassermann test	Syphilis
7.	Widal test	Typhoid
8.	Wayson stain test	Plague
9.	ELISA (NS 1) Non-Structural Protein 1	Dengue fever
10.	Lepromin test	Leprosy
11.	AIDS	ELISA test, Antibody differentiation test, western blotting, PCR for plasma HIV RNA test, Antigen p24 test

24.7.2 Viral Diseases

24.7.2.1 Influenza (Also called flu)

Acute respiratory infection by influenza viruses *(Orthomyxoviridae)* type-A, type-B, and type-C. Both A and B-type viruses are responsible for epidemics of diseases throughout the world. Type-A has the highest antigen variation and comparatively lesser in type-B influenza, with no antigenic variability in type-C; there is no cross immunity between them. Major reservoir of influenza virus exists in animals and birds. It results in *coryza* (profound discharge of running rose), sneezing, sore throat, coughing, muscle pains, headache, chill and fever. Vaccines are available against influenza Type-A.

24.7.2.2 Mumps

It is caused by a ***Myxovirus,*** which effects human glands (parotid glands) and also the nervous system of human body. It has many symptoms like ear ache, stiffness in the affected side prior to the onset of swelling. Mumps may also affect the testicles, pancreas, CNS, ovaries, prostate, etc.; infection of testicles may cause sterility. In severe cases, there may be fever, headache and other constitutional symptoms, which may last 3–5 days. Vaccination is available as MMR (Measles, Mumps and Rubella).

24.7.2.3 Measles/Rubeola

It is also caused by *myxovirus,* affecting respiratory tract and conjunctiva, which are transmitted by contact of fomite and droplet methods. In pre-eruptive stage (3–4 days), there is hoarseness, cough, sneezing, coryza, redness or watering of eyes (conjunctivitis), and blue-white Koplick's spots (with reddish base). Fourth day begins with itching, skin rash, rubeola starting from back of ears, reaching forehead, face (bloated and blotchy) and then body. The rashes begin to reduce on fifth or sixth day. Incubation period is 10 days from the onset of fever. Antibiotics and vitamin A are given to prevent complications. Vaccination (MMR of Mumps, Measles and Rubella) is available, which is given at the age of one. The infant carries passive immunity from the mother prior to this.

24.7.2.4 General Measles (Rubella)

An acute childhood infection with low-grade fever, lymphadenopathy, which is affecting of the lymph nodes and a red and flat rash. Early pregnancy infection may amount to serious congenital defects. Immunoglobin are useful and vaccination is provided as MMR.

24.7.2.5 Small Pox

Small pox has been eradicated globally. 'Edward Jenner' first developed vaccine against small pox.

24.7.2.6 Chicken Pox (Caused by Varicella Zoster)

Chickenpox is a fomite (that is clothes, furniture, etc.) transmitted, bursting/eruptive viral and contagious disease, which is common but rare in adults. Illness begins with slight fever, shivering and backache. There are then prodromal (symptom that starts before the onset of an illness) or transitory rashes. Uneasiness, aches and high fever accompany chicken pox. Itching and tendency to scratch is reduced by benzyl benzoate and calamine. There are no drugs and no vaccines for chicken pox. Antibiotics are given for life-long immunity.

24.7.2.7 Poliomyelitis/Polio

It is caused by polio virus (have RNA nucleic acid) and transmitted through faeces, urine and nasal secretions affecting grey matter of the spinal cord, resulting in inability of the head to bend forward and stiffness of the neck. It also destroys motor nerve cells in the spinal cord. It is hence called infantile paralysis. Paralysis is accompanied by high fever, headache, chilliness and pain all over the body. Involvement of the laryngeal and pharyngeal muscles proves fatal. Oral vaccines are available (developed by Jonas Salk and Albert Sabin, 1940) to protect babies from polio attack. Public Pulse Polio Immunisation Programme is organised in India for eradicating polio.

24.7.2.8 Rabies (Hydrophobia)

It is caused by Rabies virus/Lassa virus (RNA). It affects motor neurons of brains and is transmitted by the bites of carnivores. Rabies is contracted by humans through rabbit bite or saliva, dog bite, monkey, cats, etc. It leads to encephalitis, fear of water (hence called *hydrophobia*), high fever, severe headache, spasm of throat and chest, leading to death. Louis Pasteur developed vaccine against rabies.

24.7.2.9 Hepatitis

A viral infection transmitted through faecal–oral route (Hepatitis A, E) or blood-born, affecting liver with symptoms like jaundice, abdominal pain, nausea and vomiting. Contamination of water and food may cause epidemic. Serum hepatitis (Hepatitis B) spreads by transfusion of contaminated blood and blood products. Personal cleanliness, boiled water, properly heated/cooked food are to be ensured during epidemic. Vaccine is available.

24.7.2.10 Dengue Fever (Breakbone Fever)

It is an epidemic viral disease of humans caused by female tiger mosquito *Aedes aegypti,* during daytime and it is also acute tropical. Symptoms begin in 4–6 days, like sudden fever, headaches, joint and muscle pain, pain behind eye, vomiting, fatigue, nausea, skin rashes and mild bleeding (nose bleeding, bleeding in gums).

In severe cases, a person will suffer with haemorrhagic fever, a rare complication characterised by high fever. It damages lymph nodes and blood vessels in human body, bleeding from the nose and gums, swollen liver and also failure of the circulatory system. Due to progressive symptoms in dengue with massive bleeding, shock and death, it is also called as Dengue Shock Syndrome (DSS). Those people have weakened immune system and second offset of infection has maximum chances of haemorrhagic fever. People suffer with the loss of platelets in dengue. 'You and Me' campaign is related with Dengue.

Note: Female *Aedes aegypti* carries and transmits many diseases like Zika, dengue fever, chikungunya and yellow fever.

24.7.2.11 Yellow Fever

Yellow fever is a haemorrhagic disease caused by arbovirus, infected by mosquito *Aedes aegypti.* Max Theilder, in 1951, got Nobel Prize for the development of vaccine for yellow fever.

24.7.3 Protozoan Diseases

Types of protozoan diseases are Malaria, Amoebiasis, kala-azar, Trypanosomiasis, etc.

24.7.3.1 Malaria (Means Bad Air)

It is the most common protozoan diseases caused by the *Plasmodium sp. (belonging to class Sporozoa)* and transmitted by the bite of female *Anopheles* mosquito in human.

This disease is characterised by recurring rigours lasting 6–10 hours. There are three stages:

1. **Cold stage:** Chill and shivering.
2. **Hot stage:** Temperature rises to 100°F.
3. **Sweating stage:** There is perspiration and gradual fall in temperature.

Malaria results in anaemia, toxaemia and splenomegaly (enlarged spleen).

Measures against parasites of malaria

Originally, quinine derived from the bark of a Peruvian tree 'Cinchona' was used and hence, it served to be an old remedy to cure malaria.

These days synthetic drugs chloroquine phosphate and primaquine are used.

More effective than these is daraprim. It is slow in action, but in due course of time, kills the parasites both in the blood and the liver, and also in the mosquito that feeds on the blood of an infected person. Gambusia fish is also used in the protection of malaria because it eats up malaria larvae in ponds.

Karnataka sets 2027 as the target to become malaria-free

- Karnataka has set a target to eliminate malaria by 2027, three years before the 2030 target set by the Union government.
- Karnataka has received national recognition and appreciation for its efforts to eliminate malaria in the past six years, between 2015 and 2021, as part of **the National Framework for Malaria Elimination in India (NFMEI) initiative.**
- **China is the first country in the WHO Western Pacific Region** to be awarded a malaria-free certification **in more than three decades.**
- Other countries in the region that have achieved this status include Australia (1981), Singapore (1982) and Brunei Darussalam (1987).
- Globally, **40 countries and territories have been granted a malaria-free certification from WHO – including, most recently, El Salvador (2021),** Algeria (2019).

Mosquirix: The First Malaria Vaccine

- **RTS.S/ASO1 (RTS.S),** trade name **Mosquirix,** was recently endorsed by **the World Health Organisation (WHO).**
- It is **the first and, to date, the only vaccine shown to have the capability of significantly reducing malaria,** and life-threatening severe malaria, in tests on young African children.

24.7.3.2 Kala Azar (Leishmaniasis)

It is caused by *Leishmania donovani* and is spread by sandfly *(Phlebotomus)* and characterised by enlarged spleen and liver with high fever. It is also known as dumdum fever.

24.7.3.3 Ciliary Dysentery (Balantidiasis)

It is caused by *Balantidium coli*. This disease is spread through cyst formation. Cysts pass out in the host's faeces. Infection occurs by ingesting cysts with food and drinks. *Balantidium coli* cause ulcers in the colon and invades mucous membrane by secreting an enzyme, hyaluronidase. This generally results in diarrhoea, but may also lead to cysts and can prevent human infection. Tetracycline or iodoquinol are effective treatments.

24.7.3.4 Giardiasis

This is caused by *Giardia intestinalis* (first parasitic protozoan known). This disease is transmitted by contamination of cyst with food and drinks.

24.7.3.5 Trypanosomiasis

Trypanosomiasis is caused by different species of *Trypanosoma*, a flagellate protozoan. It is characterised by high fever, swelling of neck and arm, weakness, anaemia, muscle spasm, lethargy, unconsiciousness and death.

24.7.3.6 Amoebiasis (Amoebic dysentery or Enteritis)

Pathogen: *Entamoeba histolytica*

Vector: Infection by contamination

Name of the disease	Causative agent	Vector/transmitted by	Affected body part	Symptoms
Ascariasis	*Ascaris tumbricoides* (endoparasite)	Contamination of ascariasis-embryonated eggs with food and water (Vector: cockroach and vegetables).	Intestine	Weakness and anaemia (due to sharing host's food). Toxin produced by them causes colic pain indigestion, diarrhoea, vomiting, nausea, insomnia, etc. Diagnosis tests: Stool test (for eggs), scratch test and dermal test.
Ancylostomiasis	*Ancytostoma duodenate* (hookworm)	Infective larva via contaminated food and vegetables.	Intestine	Chronic blood loss, depletion of body's iron stores leading to anaemia; anal itching, inflammation of skin, irritating sores, etc.
Filariasis (also called Elephantiasis-due to enlargement of body parts, like legs)	*Wuchereria bancrofti*	Female *Culex* mosquito infects numerous microfilaria into the bloods or deposited on skin. *Culex fatigens* and *Culex pipiens* serve as secondary host for *Wuchereria*.	Leg, foot, scrotum, breast, etc.	Fever, proliferation of endothelial cells and deposition of metabolites in the walls of lymph vessels resulting in swelling of affected parts.
Taeniasis	*Taenia solium* (pork tapeworm, endoparasite)	Pig.	Intestine	Abdominal pain, indigestion, vomiting, constipation, anorexia (loss of appetite), nervous disorder.

Symptoms: *Entamoeba* secretes cytolysin that erodes the mucous membrane of intestine.

Drug: Metronidazole.

24.7.4 Helminthic Diseases

Helminthes are multicellular parasites, which cause many diseases. These consist of round-worms and flatworms. Helminthes diseases are transmitted through dirty hands, contaminated soil and food. Types of diseases are ascariasis, ancylostomiasis, filariasis, taeniasis, etc.

Cysticercosis Infection by tapeworm can also occur by taking vegetables, which are not washed properly and water contaminated with tapeworm capsules. Thus, vegetarians can also get tapeworm infection. The capsules release embryos, which may reach the eyes or brain, develop into larvae, called cysticerci that encyst. The cysts so formed may cause blindness or epilepsy like symptoms. Another species, *Y. saginat*, called beef tapeworm, causes taeniasis in beef-taking humans. Its intermediate hosts are cattle. Other disease-causing helminthes are:

- ***Enterobius vermicularis (Oxyuris):*** Called as pinworms, found in large intestine and appendix, causes anal itching, appendicitis, nervous problems. No intermediate host. Transmission is direct by contaminated food. Causes: **Enterobiasis.**
- ***Dracunculus medinensis* (Guinea worm):** These are found in the subcutaneous tissues of body. Causes: Guinea worm disease, characterised by blisters on skin. Like small pox, it is considered to be an extinct disease in India.
- ***Loa loa* (The eye worm):** Found in the subcutaneous tissues of eyes, causes conjunctivitis.
- ***Trichinell aspirilis:*** Found in the human intestine, cause muscular pains and pneumonia or Trichiniasis; transmitted by eating infected pork.
- ***Trichuris trichiura* (Whip worm):** Found in the caecum and appendix, causes anaemia, bloody stools and pain.
- ***Schistosoma haematobium:*** Causes schistostomiasis (also called Bilharzia). Transmitted by snail. Found in urinary bladder, blood vessels and causes itching, rashes, aches, fever and eosinophilia.

24.7.5 Sexually Transmitted Diseases (STD)

These diseases are sexually communicable diseases and caused by a wide range of bacterial agents, protozoan and fungal agents, viral agents and ectoparasites.

The former name of such diseases was venereal diseases (VD), which was later changed to Sexually Transmitted Diseases (STD), which indicates transformation from the past two decades.

Major sexually transmitted diseases are **syphilis** and **gonorrhoea.**

Refer to the List below for some STDs and their Pathogens.

DISEASE

Bacterial
- Syphilis
- Gonorrhoea
- Cancroid
- Vaginitis

Viral
- Herpes genitalis
- Condyloma acuminatum
- Molluscum contagiosum

Protozoal
- Trichosominiasis

24.7.6 Diarrhoeal Diseases

Diarrhoeal diseases are a group of infections of the intestinal tract. It is characterised by food poisoning, abdominal cramps, frequent passage of stool having blood and mucous, leading to dehydration.

Bacterial Diarrhoea

Bacteria causing diarrhoeal diseases are *E. coli*, *Shigella sp. Campylobacter* and *Salmonella.*

Viral Diarrhoea

- **Rotavirus** causes gastroenteritis with acute watery diarrhoea in infants and children.
- **Norwalk virus** causes gastroenteritis in all age groups.

Protozoal Diarrhoea

- ***Giardia intestinalis*** causes giardiasis.

ORS – ORS is Oral Rehydration Solution used for correcting dehydration caused by diarrhoea in all age groups. It contains 105 grams of glucose, 3.5 grams of NaCl (sodium chloride), 2.9 grams of KCl (potassium chloride) and 3.9 grams of trisodium citrate.

	Name of disease	Causative agent	Symptoms	Control
a.	Syphilis	*Spirochaete, Treponemaallidum*	Ulcer on urogenital tract, lymph nodes, hair loss, swollen joints, heart disease and blindness, etc.	Antibiotics like penicillin, tetracycline
b.	Gonorrhoea	*Neisseria gonorrhoeae*	Discharge of pus or excessive vaginal secretion, leading to eye infection in children of gonorrhoea-afflicted mothers and arthritis.	Penicillin and ampicillin

24.8 NON-COMMUNICABLE DISEASES

24.8.1 Diabetes Mellitus

It occurs due to either deficiency of insulin production or due to failure of cells to take up insulin from blood. It is characterised by **hyperglycemia** [It is a case when high glucose level is found in human blood (300–1200 mg/100 ml)]. There are many types of symptoms possible in diabetes mellitus (*Polyuria* – excessive urination due to increase in water content of urine, *Polydipsia* – excessive thirst, *Glycosuria* – glucose in urine, *Polyphagia* – excessive eating). Loss of weight, tiredness, dehydration, reduced healing power and blurred vision are some other prominent symptoms. Two types of diabetes are more prominent in human beings – Type-I and Type-II.

(a) **Diabetes Mellitus Type-I (Insulin-Dependent Diabetes):** It is in a category of autoimmune diseases (are those when body destroys good stuff in our body). In this type of diabetes, insulin synthesis does not increase during the consumption of sugar content. In the majority of cases, this type of diabetes appears before the patient is 40 years old. That is why this type of diabetes is also known as *Juvenile Diabetes* or *Childhood Diabetes*. About 15 per cent of all diabetes patients have Type-I.

DIABETES MELLITUS *vs* DIABETES INSIPIDUS

Diabetes Mellitus is the problem of insulin hormone due to either destruction of Islet of Langerhans cells present in the pancreas or any other autoimmune cause. Here, there is increased level of sugar in blood. It can cause death when its level rises beyond a certain limit.

Diabetes Insipidus is the defect in secretion of vasopressin hormone (antidiuretic hormone), which is secreted from posterior pituitary gland present in hypothalamus. Its deficiency than the normal level increases dehydrolysis (removal of water through urine) even in low intake of water.

Note: Caffeine consumption also decreases ADH level in human body, which induces dehydrolysis (more urination/ increased removal of water through urine).

(b) **Diabetes Mellitus Type-II (Insulin-Independent Diabetes):** Two reasons behind Diabetes Mellitus Type-II: (1) Not enough insulin is being produced. (2) The insulin is not working properly – this is known as *insulin resistance* (The body produces insulin, but its insulin sensitivity is undermined and does not work as it should do – glucose in not entering the body's cells properly). Approximately 85 per cent of all diabetes patients have Type-II.

24.8.2 Cardiovascular Diseases

Hypertensive heart disease results in the damage of heart muscles and brain stroke (resulting in paralysis; loss of speech and other functions).

- **Arteriosclerosis:** Thickening of arteries and arterioles, resulting in blood pressure higher than normal.
- **Atherosclerosis:** It is the disease when arteries and arterioles become narrow because of fat deposition inside and over the tunica intima (inside blood vessel). It leads to high blood pressure, clot formation or *thrombosis*.

Coronary Heart Disease

- **Angina pectoris:** Severe temporary heart pain, spreading especially to the left arm because of deficient oxygen supply or myocardial ischemia/ reduced blood supply.
- **Heart attack:** Formation of a clot (thrombus) in a narrowed coronary artery stops blood supply to the part of the heart muscle beyond the clot. The muscle cells of this part due to lack of oxygen and glucose. This condition is called 'heart attack' (coronary thrombosis or myocardial infarction) or MI.
- **Rheumatic heart disease:** The rheumatic heart disease is common in India under 20 years of age. In Rheumatic fever (due to *Streptococcal* infection), toxins are produced causing inflammation of different parts of the body, which also include endocardium (it is the inner most layer of tissues that lines the chambers of the heart) and joints. They give rise to murmur (heart sounds produced when blood flows across one of the heart valves), which are pathological (abnormal) heart sounds heard through a stethoscope.

Prevention of heart disease Certain precautions can prevent heart diseases. These are as follows:

(i) Avoid strain by keeping cool in all circumstances.

(ii) Avoid saturated fats, especially after 35 years of age, to keep cholesterol level of the blood low, smoking, drinking drugs.
(iii) Avoid becoming overweight and obese (bulky).
(iv) Take light exercise daily.
(v) Take preventive measures against infections of respiratory tract.
(vi) Consult a doctor in case of any pain in the chest.

Stroke Stroke is cerebrovascular damage due to stopping of blood to a part caused by following reasons:
(a) Clot/thrombus
(b) Breaking of an artery because of its wall weakening and hypertension
(c) Sustained contraction or spasm of an artery

Such a stroke leads to paralysis, losing of consciousness, loss of hearing and even death.

24.8.3 Arthritis

Common disease of old age, inflammation of joints and muscles resulting in pain and stiffness of the joints. This disease is of several types:
(a) **Osteoarthritis:** Wearing or breaking down of the cartilage that covers every end of the bones, causing great pain in the movement of joints and in future developed into bony spurs.
(b) **Rheumatoid arthritis:** Erosion of joints due to unexpected attacking by the immune system of the body causing inflammation of the joints with great pain due to thickening of the tissue lining the joints; women are more often affected than men.
(c) **Gout:** This occurs in men, especially, in which sodium urate crystals and uric acid in excess form are gathered or deposited in the synovial joints, which causes arthritis with pain at night making it difficult to move.

Osteoporosis Denotes a condition wherein an imbalance between the new bone formation and old bone reabsorption occurs. Either the body fails to form enough new bone, or there is too much old bone reabsorption, or even both can lead to it.

Diagnosis A bone mineral density test (BMD test) uses X-rays for measuring the amount of minerals, i.e., calcium in the bones. This test greatly helps people who are at risk of osteoporosis, especially the women and older adults. Another name for the test is dual energy X-ray absorptiometry (DXA).

24.8.4 Kidney Stones

They are common urinary tract disorder that involves crystallised chemicals like uric acid, calcium oxalate and calcium phosphate (Renal Calculi).

Treatment A medical procedure, which is used to treat certain types of kidney stones as well as stones in other organs, like the gallbladder or the liver, is termed as Lithotripsy.

This procedure uses sound waves (also known as high-energy shock waves) for breaking up large kidney stones into smaller pieces. Extracorporeal shock wave lithotripsy (ESWL) denotes the most common form of lithotripsy.

24.9 OCCUPATIONAL DISEASES

Occupational diseases arise among those people who are exposed to air pollutants generated from the industries where they are working. Types of occupational disease are asbestosis, silicosis, byssinosis, bagassosis, anthracosis, etc.

(i) **Asbestosis** is characterised by pulmonary fibrosis leading to respiratory insufficiency and death, carcinoma of bronchus and gastrointestinal tract, etc.
(ii) **Silicosis** is a disease of the lungs caused due to inhalation of silica-containing dust.
(iii) **Byssinosis** is characterised by chronic cough, progressive dyspnea, ending in chronic bronchitis and emphysema.
(iv) **Bagassosis** is characterised by breathlessness, cough, haemoptysis and slight fever.
(v) **Anthracosis** is characterised with little ventilator impairment; progressive massive fibrosis causes severe respiratory disability and results in premature death.

Types of air pollutant	Dust	Disease
Inorganic	Coal dust	Anthraxosis
	Silica	Silicosis
	Asbestos	Asbestosis (lung cancer)
	Iron	Siderosis
Organic	Cane fibre	Bagassosis
	Cotton dust	Byssinosis
	Tobacco	Tobacossis
	Hay/grain dust	Farmer's lung

All these diseases are caused by dust, called pneumoconiosis. Pneumoconiosis may gradually cripple a man by reducing his working capacity because of lung fibrosis and other complications.

Oxides of sulphur and its hydrates, H_2SO_4 in moderate concentration, cause suffocation and irritation in the upper respiratory tract and continuous exposure may cause lung diseases like chronic asthma, bronchitis, unconsciousness and even death.

Note: Carbon Monoxide Poisoning: A poisonous gas with no smell or taste, breathing in which can make you unwell, could even kill on being exposed to high levels of it, is called carbon monoxide (CO). It is produced on complete burning of fuels like gas, oil, coal and wood.

How it affects:

- On being breathed in, CO enters the bloodstream and thus mixes with haemoglobin (the pigment in RBCs, carrying oxygen around the body), to form carboxyhaemoglobin.
- And hence, it reduces the oxygen-carrying capacity of the blood and this lack of oxygen leads to body's cells and tissues to fail and ultimately die.

24.10 VITAMINS

Funk (a Polish biochemist) is generally credited with being among the first to formulate the concept of vitamins, in 1912, which he called 'vital amines' or 'vitamines'. Vitamins are non-energy producing organic substances, which are vitally essential in traces for proper use of macronutrients in cell metabolism (because they play a role in energy transformations, usually acting as coenzyme in enzymatic system) and hence for proper growth and function (**Table 24.2**). They cannot be synthesised within the body, so must be acquired from exogenous source, i.e., diet. Vitamins are synthesised mostly by plants and certain intestinal bacteria. On the basis of their solubility in fats and water, vitamins are divided into two main categories: fat-soluble (A, D, E, K) and water-soluble vitamins (B, C).

24.10.1 Water-Soluble Vitamins

These vitamins help in energy production from fats and carbohydrates. Excess of these vitamins are excreted in the urine, which are generally non-toxic and there is a need for continuous supply of these vitamins in our diet. In addition, several other water-soluble substances are necessary as growth factor for some organisms but they occur in more than trace amounts. These groups include Inositol and choline. The deficiency of these vitamins greatly affects growing tissue like skin, the digestive tract, blood and the nervous system.

24.10.2 Fat-Soluble Vitamins

These vitamins are non-polar hydrophobic molecules, derivative of isoprene. They are digested and absorbed by fats to be transported in the blood. Most fat-soluble vitamins contain at least one -OH group (hydroxyl group), which results in ester formation with the fatty acids. Therefore, vitamins are soluble in organic solvents (like chloroform). These vitamins are toxic, if consumed in higher amounts. Vitamins A and D cause specific cells to decrease or increase certain genes' expression with their hormone actions. Only higher animals appear to require them from exogenous sources. An essential role of fat-soluble vitamins in plants and microorganisms has not been clearly established. They do not appear to serve as component of coenzyme.

Note: **Hypervitaminosis** is the condition when there is excess of overall vitamins.

TABLE 24.2 Different types of vitamins, their chemical names, functions and deficiency problems in human body

Name	Sources	Functions	Effect of deficiency
WATER-SOLUBLE VITAMINS			
1. B1 (Thiamine)	Rice bran, whole-wheat flour, oatmeal, eggs, yeast, meat, liver, etc.	Major component of coenzyme carboxylase required for carbohydrate and amino acid metabolism	Beri-beri: loss of appetite and vigour, constipation, weak heartbeat, muscle atrophy, even paralysis.
2. B2 (Riboflavin)	Cheese, eggs, yeast, tomatoes, green vegetables, liver, meat, cereals, etc.	Combines with phosphoric acid to form coenzyme FAD essential for oxidative metabolism	Cheilosis (fissures at the corners of mouth and lips), digestive disorders, burning sensations in skin and eyes, headache, mental depression, scaly dermatitis at angles of nostrils, keratitis of cornea, glossitis (inflammation of tongue).

	Name	Sources	Functions	Effect of deficiency
3.	B3 (Nicotinic Acid Or Niacin)	Yeast, liver, cereals, fresh meat milk, pulses, fish, etc.	Active group in coenzyme Nicotinamide Adenine Dinucleotide (NAD) required for oxidative metabolism	Pellegra, a vitamin B3 deficiency disease is characterised by dermatitis (inflammation of skin), diarrhoea, dementia and death, hence called 4D-Syndrome), muscle atrophy, inflammation, inflammation of gut mucous membrane, nervousness, headache, fatigue, mental depression, etc.
4.	B6 (Pyridoxine)	Cereals, fish, meat, yeasts; Synthesised by intestinal bacteria	Coenzyme required in protein and amino acid metabolism	Dermatitis, anaemia, Convulsions, nausea, vomiting, mental disorders.
5.	B5 (Pantothenic Acid)	Milk, all food; more in yeast, liver, kidneys, sugarcane eggs, eats, groundnut, tomatoes	Co-A required for oxidative metabolism	Gastrointestinal disorders, anaemia, reduced secretion of steroid, hormones, burning feet syndrome, fatigue, nausea, fatty liver in man.
6.	Vitamin H (Biotin)	Yeast, vegetables, fruits, wheat, eggs, chocolate	Essential for lipid synthesis and energy production groundnut; synthesised by intestinal bacteria	Skin lesions, loss of appetite, weakness. Hairfall, anorexia.
7.	Folic Acid group	Soyabean, kidneys, yeast, green vegetables, liver; synthesised by intestinal bacteria	Essential for synthesis of DNA and maturation of blood corpuscles	Retard growth, megalo-blastic anaemia, (low haemoglobin content).
8.	B12 (Cyanoco-balamine)	Milk, fish, eggs, meat; synthesised by intestinal bacteria	Required for chromosome duplication and formation of blood corpuscles	Retard growth, Pernicious anaemia due to production of Haemoglobin free immature RBCs as a result of deficient intrinsic factor.
9.	Vitamin C (Ascorbic Acid)	Citrus fruits, tomatoes, green vegetables, pepper, potatoes, etc.	Collagen formation, bones, cartilage, teeth, and RBCs, connective tissue, and for fe+ metabolism	Scurvy (also called sailor's disease), characterised by wound-healing and growth retardation; breakdown of immune defence system; gums bleeding.
			FAT-SOLUBLE VITAMINS	
10.	Vitamin A (Retinol)	Synthesised in cells of liver and intestinal mucous membrane from carotenoid pigments	Anti-infective, essential for synthesis of visual pigments; growth and epithelial division of cells	Xerophthalmia (is due to non-function of lacrimal gland of conjunctiva) is characterised by keratinised conjunctiva and soft cornea, which is opaque. Night blindness, (nyctalopia, a disturbance of rod vision); impaired growth glandular secretion and reproduction.
11.	Vitamin D (Ergocalciferol and Cholecalciferol)	Synthesised in skin cells in sunlight from 7-dehydrocholesterol, i.e., pro-vitamin D3	Absorption of Ca+ and P in the intestine, deposition of mineral in teeth and bones.	Deficiency causes Rickets, a disorder of children of 6 months to 2 years, due to deficient ossification of bones is characterised with bending of bones and swelling joints. Osteomalacia refers to a disorder of adults, which is characterised by fragility of bones. It is typically weakening of the bones. The problems with bone-building process and bone formation or with the cause osteomalacia. [Hypervitaminosis of Vitamin E results in deposition of calcium in soft tissue.]

	Name	Sources	Functions	Effect of deficiency
12.	Vitamin E (Tocopherol)	Green vegetables, oils, wheat, yolk, egg, animal tissues	Important for pregnancy lactation, spermatogenesis and muscular function	Reversible sterility in female, characterised by normal ovulation, fertilisation and implantation but foetus is resorbed in the uterus after some time. In males, it causes atrophy of spermatogenic tubules of testes so causes sterility. Muscular dystrophy, anaemia due to increased breakdown of blood cells.
13.	Vitamin K (Phylloquinone)	Yolk, carrot, cheese lettuce, liver, egg, tomatoes and others	Acts as an anti-haemorrhagic factor essential for pro-thrombin synthesis in liver, required for blood clotting	Excessive bleeding if injured (haemorrhages) because of delayed blood-clotting; this condition is called hypoprothrombinemia.

Note: Besides the vitamin-deficiency diseases, other important deficiency diseases involve that of proteins, namely Marasmus and Kwashiorkor, both being type of under-nutrition.

- **Marasmus:** Its occurrence is more often in young children and babies. The disease leads to weight loss and dehydration. Starvation is a form of this disorder.
- **Kwashiorkor:** People with severe protein deficiency may suffer from it. Children developing kwashiorkor are often older than those who develop marasmus. A diet that consists mainly of carbohydrates can lead to this condition.

PART B: POPULAR AND RECENT DISEASES WITH VARIOUS ISSUES

24.11 POPULAR AND RECENT DISEASES IN NEWS

24.11.1 Cancer

Hippocrates is a Greek physician and also called as 'Father of Medicine'. He has given the term Cancer, which means crab. Various agents are known to cause cancer, namely, genetics, tobacco consumption and radiation exposure.

Symptoms Cancer does not have any specific symptoms. Many symptoms are possible, like: abnormal lumps, changes in your skin, persistent cough or hoarseness, unexplained weight loss, constant fatigue, persistent pain, indigestion or trouble swallowing, changes in bowel habits.

Various treatments are adopted against cancer Stem-cell therapy; Drug treatment, which is also called Chemotherapy; Immunotherapy for improving immune system and vaccines, surgery; Radiation therapy using x-rays, gamma rays, bone-marrow transplantation, etc.

Steps taken by Government In 1975, initiation of the National Cancer Control Programme (NCCP) took place and later, in 1984–85 focussed on detection and prevention of cancer at early stage. In 2010, National Programme for Prevention and Control of Cancer, Diabetes, Cardiovascular Disease and Stroke (NPCDCS) was launched by the government, which emphasised on three main sites of cancer: cervical, oral and breast. Later, during 2013–14, NPCDCS was brought under 'National Health Mission' for early detection of cancer, diagnosing and treatment and also prevention of cancer.

Twenty (20) State Cancer Institute (SCI) and Fifty (50) Tertiary Cancer Centres in different parts of India are to be assisted or given assistance by the government, under the NPCDCS Scheme 'Strengthening of tertiary care of cancer', ₹120 crore and ₹45 crore, respectively.

In 2009, under the Rashtriya Arogya Nidhi, the 'Health Ministers Cancer Patient Fund (HMCPF)' was set up to provide funds for immediate financial assistance of up to ₹2 lakh to Below Poverty Line Cancer patients through Regional Cancer Centres, by providing them the fund.

24.11.2 AIDS (Acquired Immuno-Deficiency Syndrome)

Scientists found out the source of HIV infection in humans from a type of chimpanzee in West Africa. Simian Immune Deficiency Virus (SIV) of chimpanzee was contracted and transferred to humans and in which mutation occurs, leading to HIV when it comes in contact with their infected blood. The virus slowly speeded across Africa and then later on to other parts of the world.

Causative Agent HIV is caused by **lentivirus.** Lentivirus is from Retro-viridae family, having long incubation period.

Symptoms Dry coughing or breath shortness, diarrhoea, pneumonia-like symptoms, fever and white spots, loss of vision and memory loss, severe headaches with neck stiffness, vomiting, nausea, lacking of coordination, depression and confusion, seizure or epilepsy.

HIV or **Human Immunodeficiency Virus** represents the virus that causes this disease, and leads to the initial stage of infection, while AIDS, that is Acquired Immuno-Deficiency Syndrome represents the set of symptoms or syndrome so developed in the later stage of this infection, when the immune system of the infected person becomes too weak.

Government Measures

- NACO (National AIDS Control Organisation) In 1986, Ministry of Health and Family Welfare constituted the National AIDS Committee. National AIDS Control Organisation (NACO) was also constituted to implement India's first National AIDS Control Programme, which was launched in 1992. NACO provides leadership to HIV/AIDS control programme in India through thirty-five (35) HIV/AIDS Prevention and Control Societies.

The HIV and AIDS (Prevention and Control) Bill, 2017

The Human Immunodeficiency Virus and Acquired Immune Deficiency Syndrome (Prevention and Control) Bill, 2017 was introduced in Parliament in 2014 and became effective from 10 September 2018. With the passing of this Act, India reportedly became the first country in south Asia to statutorily prohibit discrimination against people diagnosed with HIV/AIDS.

A person's HIV status should not be disclosed except with his informed consent or court order. Data protection measures should be adopted during all records. This law ensures that without the consent of a person, HIV test, medical treatment or research should not be conducted.

The Bill prohibits discrimination against persons living with HIV/AIDS for the purposes of employment, provides for access to educational establishments of such persons, along with access to healthcare and insurance services, renting property, or running for public or private office etc. HIV test is also not required to obtain any job. This bill provides immense support to National AIDS Control Programme (NACP) to achieve the target of ending this epidemic disease by 2030.

PROJECT SUNRISE

For the prevention of AIDS in the eight north-eastern states, the government has launched a project called 'Project Sunrise' to create awareness about the disease in the North-East states. Although the North-East is less populated, it has, in comparison to other Indian states, some 1,00,000 people living with this condition.

24.11.3 HIV/AIDS Act, 2017

A notification has been issued by The **Ministry of Health and Family Welfare** for bringing the ***Human Immunodeficiency Virus and Acquired Immune Deficiency Syndrome (Prevention and Control) Act, 2017*** in force from 10th September, 2018. This Act will safeguard the rights of people living with HIV and affected by HIV.

Highlights of the Act

1. **Provisions have been made related to the role of governments:** As per the Act, central and state governments **provide for anti-retroviral therapy (ART)** and management of opportunistic infections (infections that take advantage of weakness in the immune system and occur frequently). **It also forbids specific acts of discrimination by the state, or any other person, against HIV-positive people, or those living with such people.**
2. **Provisions related to discrimination:** It has laid down penal provisions for any discrimination practiced against a person with HIV/AIDS and breach of confidentiality. **The protection mandates its extension to the fields of healthcare services, educational services, employment, public facilities, property rights, holding public office and insurance.** It also provides for **confidentiality of HIV-related information** and has made it necessary to get informed consent for undertaking HIV tests, medical treatment and research.
3. **Provisions related to ombudsman: An ombudsman will be appointed by respective state government to enquire into complaints related**

to the violation of the Act and the provision of health care services. A report shall be submitted to the state government every six months stating the number and nature of complaints received, the actions taken by the Ombudsman.

4. **Provisions related to supervision:** There are provisions related to supervision. A person with sufficient maturity level aged between 12 to 18 years who knows how to manage the affairs of his HIV or AIDS affected family shall be competent to act as a guardian of another sibling below 18 years of age. **The guardianship will be applied in matters relating to admission to educational establishments, operating bank accounts, managing property, care and treatment, amongst others.**
5. **Role of courts: The Court must dispose off cases relating to HIV-positive persons on a priority basis.** While dealing with legal proceeding, if an HIV infected or affected person is a party, the court may pass orders that the proceedings be conducted (a) by hiding the identity of the person, (b) in camera, and (c) to restrain any person from publishing information that discloses the identity of the applicant. Medical expenses incurred by the applicant should be taken into account when any order is passed with regard to a maintenance application filed by an HIV infected or affected person.

Background

Around 21 lakh persons have been estimated to be living with HIV in India and the percentage of patients receiving anti-retroviral therapy (ART) treatment currently stands at a mere 26.82% as against the global percentage of 41%, according to the 2015 Global Burden of Diseases (GBD).

24.11.4 Influenza

An influenza virus causes it. Three types of seasonal influenza viruses are present: (1) Influenza A; (2) Influenza B and (3) Influenza C. These viruses have different subtypes on the basis of various combinations and their surface proteins. In comparison to Influenza type A and Influenza type B, there is less case of occurrence for Type C Influenza. So the Influenza A and Influenza B viruses are included in seasonal influenza vaccines.

Haemogglutinin (H) and Neuraminidase (N) proteins cover the surface of Influenza A and Influenza B viruses (**Figure 24.1**).

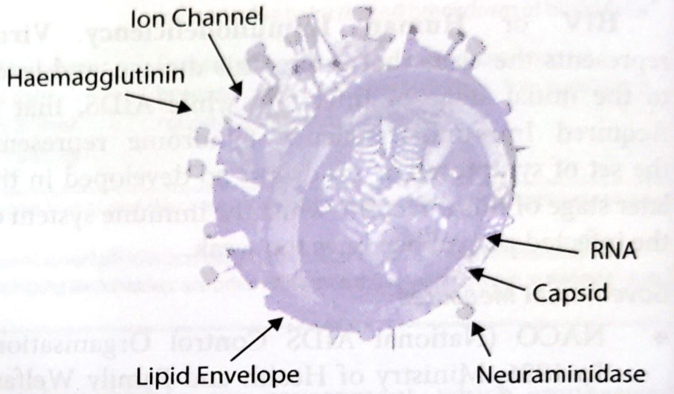


Figure 24.1
Structure of the influenza virion.

In Influenza type A virus, there are 17 haemagglutinin types, ranging from H1 to H17 and 9 neuraminidase types, N1 to N9. Each influenza virus has at least one type of H (such as H1) and one type of N (such as N1).

The seasonal influenza A strains H1N1 and H3N2, currently circulating in humans, have contributed to lot more changes since their first introduction into humans.

Influenza type B strains circulation is not in animals, hence it cannot cause a pandemic. But, like influenza type A viruses, they continually change, so they are not immune to every strain. The other components of the flu vaccine are as follows:

H1N1 – (Spanish Flu, and Swine Flu)
H1N2 – (endemic in birds, human and pigs)
H2N2 – (Asian Flu) H3N2 – (Hong Kong Flu)
H5N1 – (Bird Flu)
H7N7 – (Zoonotic potential)
H7N2, H7N3
H9N2, H10N7

Symptoms Dry cough, headache, high fever, severe malaise, sore throat and runny nose, muscle and joint pain. Influenza can cause disease or illness or even death, especially in people at high risk (**Figure 24.2**).

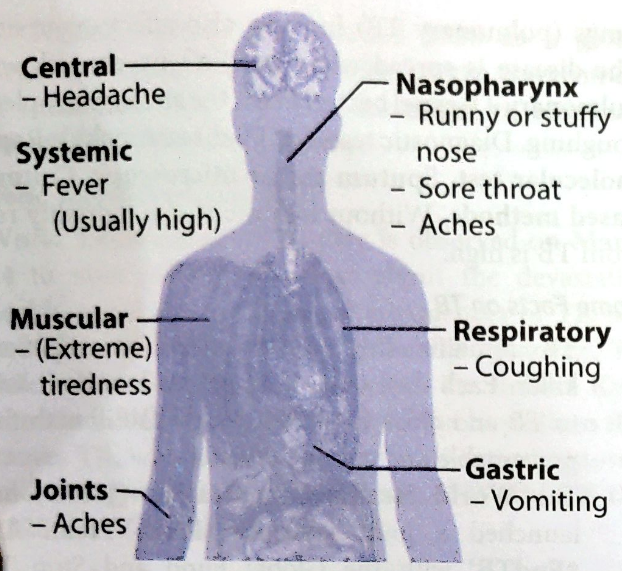


Figure 24.2
Symptoms of Influenza Disease

Cure There are two classes of such medicines: Inhibitors of influenza neraminidase (zanamivir and oseltamivir), adamantanes (rimantadine and amantadine). Some influenza viruses have been reported to develop resistance to the antiviral medicines, thus, limiting the effectiveness of treatment.

Differences between H1N1 Flu and Influenza Type A

This H1N1 flu is a variety of Influenza type A. indicating the viral serotype; it is a type of shorthand for characteristics, which identify the virus to your immune system and enable the virus to enter your cells. H1N1 also has different strains of H1N1 flu.

24.11.5 Ebola

History Ebola (named after the Ebola River in Zaire) first emerged in Sudan and Zaire in the year 1976. The first outbreak of Ebola (EBOLA-Sudan) was reported to infect over 284 people, with a mortality rate of 53 per cent. Later, after a month, the second Ebola virus emerged from Yambuku, Zaire, Ebola-Zaire (EBOZ).

Causative Agent Ebola virus is from filoviridae family and from the order mononegavirales. The causative agent of Ebola Hemorrhagic Fever (Ebola HF) is Ebola virus. The Ebola and Marburg viruses, from the filoviridae family, are among the most virulent pathogens in humans.

Symptoms Diarrhoea, red eyes, vomiting, raised rash, cough, bleeding from the eye usually, chest pain, severe weight loss, bruising and internal bleeding.

DIFFERENCES BETWEEN SWINE FLU AND BIRD FLU

Swine Flu

It is a disease caused by H1N1 Virus. It infects people, pigs, birds and other animals. Swine flu is reported to normally infect pigs. Occasionally, the pigs transmit influenza viruses to people, mainly to hog farm workers and veterinarians. This flu also spreads quickly, affecting the respiratory system, but casualty rate is less as compared to Bird flu. Persons having chronic medical conditions and pregnant woman are vulnerable targets. Symptoms include diarrhoea, vomiting, coughing and fever.

Bird Flu (Avian Influenza)

It is a disease caused by H5N1 virus, carried by animals, especially birds, which rapidly spreads and causes sudden death of the one who is infected. The outbreak of avian influenza (H5N1) – started in poultry in South Korea in mid-December 2003, and affecting birds in many countries in Middle East, Africa, Europe and Asia. Bird flu spreads very slowly, but casualty rate is higher. Bird flu virus affects all human body systems. Symptoms include pneumonia, eye infections and other problems. Rural workers and children are victims who get infected with Bird flu.

Treatment No specific treatment; Patient is to be managed in isolation facilities for preventing spreading of the infection. Intensive supportive care is required for very ill patients. Oral rehydration with solutions containing intravenous fluids or electrolytes is required as patients get dehydrated. Strict infection control measures by the health workers when caring for suspected patient.

Cure No vaccine for EBOLA. Experimental vaccines are under development, but not yet been fully tested for effectiveness or safety.

Important preventions measures for travellers to be observed: Avoid travelling to affected areas, have good personal and environmental hygiene, use liquid soap or alcohol-based hand rub for cleaning hands before touching the nose, eyes and mouth, close contact with ill-persons, and avoid contact with blood or bodily fluids of patients, which includes items that may have come in contact with the infected person's blood or bodily fluids.

Contact with animals also needs to be avoided. Food should be thoroughly cooked before consumption; a close observation of the health conditions for 21 days after returning from an affected area. **The Government had advised Indians against non-essential travel to the four West African countries namely Guinea, Sierra Leone, Liberia, and Nigeria which were the epicentre of Ebola.**

24.11.6 Severe Acute Respiratory Syndrome (SARS)

History This disease was initially transferred to humans through civets, mammals with catlike appearance. In 2002, SARS virus was firstly reported in Asia. As per the World Health Organization (WHO), July 2003, it causes death of many people worldwide due to its epidemic nature. This disease was reported in more than 30 countries in five continents.

Causative Agent Severe Acute Respiratory Syndrome (SARS) is the term for a viral respiratory illness caused by a corona virus – the (SARS-CoV). Corona viruses are a group of viruses that have crown-like (corona) or halo-like appearance on viewing under a microscope and are a common cause of moderate-to-mild upper-respiratory illness in humans and causing severe diseases in animals like gastrointestinal, liver, respiratory and neurologic diseases.

Symptoms Fever, runny nose, headache, fatigue, muscle pain and ache, malaise (general discomfort feeling), decreasing appetite, diarrhoea, cough (dry), breath shortness, sore throat.

Cure There is no cure for SARS but researchers are trying to find a vaccine. Treatment may include:

- Assistance with breathing by using a ventilator to deliver oxygen.
- The antibiotics to treat bacteria that cause pneumonia.
- The antiviral medications.
- High steroid doses for reducing swelling in the lungs.

24.11.7 Tuberculosis

TB is an infectious disease caused by **a bacterium *Mycobacterium tuberculosis*.** It typically affects the lungs (pulmonary TB) but can also affect other sites. The disease is spread when people who are sick with pulmonary TB expel bacteria into the air, for example by coughing. Diagnostic tests for TB disease include **Rapid molecular test, Sputum smear microscopy, Culture-based methods.** Without treatment, the mortality rate from TB is high.

Some Facts on TB

- TB remains the world's deadliest infectious killer. Each day, over 4000 people lose their lives to TB and close to 30,000 people fall ill with this preventable and curable disease.
- The **World Health Organization (WHO)** has launched a joint initiative **'Find. Treat. All. #EndTB'** with the Global Fund and Stop TB Partnership, with the aim of accelerating the TB response and ensuring access to care, in line with WHO's overall drive towards Universal Health Coverage.
- WHO publishes **a global TB report** every year since 1997.

Initiatives in India

1. TB treatment is free in India.
2. **Mass BCG vaccination** to prevent TB.
3. In 1993, **the Revised National TB Control Programme (RNTCP)** was launched, offering free diagnosis and treatment for patients, rescuing them from otherwise sure death.
4. ₹12,000 crore fund to fight TB over the next 3 years.
5. **'TB Harega Desh Jeetega Campaign'** has been launched with an aim to eliminate tuberculosis from India.

About 'TB Harega Desh Jeetega' Campaign

- **Campaign aims to** improve and expand the reach of TB care services across the country by 2022.
- **Three pillars of the campaign** – clinical approach, public health component and active community participation.
- **Supporting aspects of the campaign** – patient support, private sector engagement, political and administrative commitment at all levels.
- **The government will ensure that** all patients, at private or public hospitals, receive free-of-cost and high-quality TB care.

United Nations has marked **2030 as a global target to eliminate TB worldwide** but the Government **of India has made 2025 as its target to eliminate tuberculosis from the country.**

World Tuberculosis Day 2021

World Tuberculosis (TB) Day is observed on **March 24** to raise public awareness about the devastating health, social and economic consequences of TB, and to step up efforts to end the global TB epidemic. The date marks **the day in 1882 when Dr Robert Koch announced that he had discovered the bacterium that causes TB,** which opened the way towards diagnosing and curing this disease. **The theme of World TB Day 2023** was ***'Yes! We can end TB!'***.

Sustainable Development Goal (SDG)

- The consolidated goal on health is **SDG 3**. One of these targets, **(Target 3.3)**, explicitly mentions TB.
- **SDG 3 also includes a target (Target 3.8)** related to universal health coverage (UHC) in which TB is explicitly mentioned. This includes an indicator on the coverage of essential prevention, treatment and care interventions.

24.11.8 Meningitis

It is a rare infection that affect meninges layer which covers brain and spinal cord. Bacteria, virus and fungi are causing agents of meningitis. Bacterial meningitis is more contagious among people and can cause death. Viral meningitis is comparatively less severe and fungal meningitis is very rare form of meningitis.

Bacteria can be transmitted through coughing and sneezing from one person to the other. Bacteria travel through the bloodstream to the brain. Many bacteria are responsible for Meningitis: *Neisseria meningitidis, Streptococcus pneumoniae, Listeria monocytogenes, Haemophilus influenzae* type B. Most risky people to suffer from Meningitis: Meningitis is more dangerous for people with certain medical conditions, like absent or damaged spleen, immune system disorders, or chronic disease. Following are the most common symptoms of meningitis:

- Persistent and severe headache
- Stiffness of the neck and painful neck
- Vomiting
- Confusion and decrease in the level of consciousness
- Seizures

Other symptoms of meningitis may include Sluggishness, weakness and strange feelings (as tingling), muscle ache or weakness throughout the body. Eye becomes sensitive and eye pain from bright lights, skin rash and dizzy spells, etc.

Antibiotics for Bacterial Meningitis

Branded Name: Rocephin, Claforan

Generic Name: Ceftriaxone, Gentamicin, Vancomycin, Vancocin, Rifampin, Cefotaxime, Claforan, Penicillin G

GLOBAL ROADMAP TO DEFEAT MENINGITIS BY 2030

- The Global Roadmap to Defeat Meningitis by 2030 was recently released by **the World Health Organization (WHO)** and its partners.
- This is **the first-ever global strategy to defeat meningitis.**
- It aims to eliminate epidemics of bacterial meningitis and to reduce deaths by 70% and halve the number of cases.

24.11.9 Encephalitis

From the last few years, Japanese Encephalitis became a cause of many deaths of children and old-age people in eastern Uttar Pradesh. This disease is spread through contaminated water and carrier mosquito (female culex/ Tiger Mosquito). Though there are no antiviral drugs developed till date but researches are underway to find the cure. Those people suffering with viral encephalitis are kept in fluids while monitoring for brain swelling. Japanese Encephalitis virus can infect the foetus and cause death.

24.11.10 Dengue

It is a viral disease spread due to bite of female Aedes mosquito. Dengue is also called as **break bone fever.**

Symptoms of Dengue Fever Severe headaches, pain behind the eye, sudden high fever, nausea, severe muscle and pain, vomiting, skin rash, appearing three to four days after the onset of fever, mild bleeding (such as gums bleeding, easy bruising, nose bleed). In dengue infection, a person gets deficient in the human body with blood platelets.

Mostly younger children and old age people suffer due to this infection. Dengue haemorrhagic fever is a serious dengue, those appear in high fever, damage to blood vessels and lymph nodes, in severe cases have also bleeding from the gums and nose, liver will enlarge, and at last circulatory system stops to work. This is also called as dengue shock syndrome (DSS). This disease mostly occurs in people having weaker immune system.

Treatment for Dengue Fever

At present we don't have specific medicine for treating dengue infection. Pain relievers with acetaminophen can be used and medicines with aspirin as a constituent is to be avoided as it, could worsen bleeding. Resting, drinking plenty of fluids, and seeing a doctor is necessary.

24.11.11 Chikungunya

Chikungunya also often known as the 'monsoon disease' spread to people by the bite of an Aedes mosquito carrying the chikungunya virus.

Symptoms of Chikungunya Overwhelming fatigue; inability to complete normal chores, weakness, high fever, pain/stiffness in the joints, headache, muscle pain, certain body parts, which are in pain may also swell up, sleeplessness, rashes in the body, nausea, ulcers in the mouth. It can be up to 12 days after being infected, that these symptoms begin to surface. There are times where infection occurs but no symptoms manifest. This situation/condition is known as silent chikungunya. People of any age group can suffer with this disease.

Cure No cure for chikunguyna. Once contracted, the body develops immunity to it and will not suffer from it again. So it is important to be aware of the symptoms, to catch it early and get it treated so that we can recover fully and remain protected in the long run from contracting it again.

Treatment Tulsi and carrots are recommended for effective recovery. Ayurvedic medicines that are made of several herbs, spices may be prescribed. Ayurvedic doctor can be visited for a check-up and individual treatment options.

Taking good care of our health has a big role to play in preventing chikungunya.

- Eating healthy food to build the immune system. Focussing on nuts, fruits, vegetables, seeds, fish, eggs, grain and lean meat and avoiding street food, fast food and greasy dishes.
- Regular exercise also helps makes the body stronger.
- Vitamins C, E help boost immunity. If daily requirement is not fulfilled through food, vitamin pills can be taken.
- Learning stress management, since stress has a debilitating effect on our immune system and hence the raises risk of catching infections.

24.11.12 Zika Virus

During 1947, this disease was firstly reported in Uganda, in monkeys. But first, human case was detected in 1954 in Nigeria. Later, this disease spread in many continents, including Africa, South East Asia and Pacific Islands.

Countries Affected Outbreaks of Zika virus disease have been recorded in Africa, the Americas, Asia and the Pacific.

Cycle of Spread Aedes mosquitoes spread Zika virus worldwide.

Symptoms Most virus carriers are without symptoms. It is a silent infection in a group of highly vulnerable individuals – pregnant women who, in turn, have a horrible outcome for their babies.

Vaccines developed so far It was reported by US-Brazilian team of scientists, that two distinct vaccine candidates conferred powerful protection from the Zika infection when each vaccine was delivered by intra-muscular injection to mice. Scientists at Bharat Biotech International Ltd, Hyderabad, claim to have developed a Zika virus vaccine for humans and have patented it too. It is a big breakthrough by the Indian scientists to control the epidemic affecting the Americans. Trials are going on for the vaccine.

WOLBACHIA METHOD

Aedes mosquitoes are introduced with the bacterium in the Laboratory and then researchers release them into the wild.

It will compete with various viral diseases – dengue, zika, chikungunya, yellow fever, West Nile fever etc.

Wolbachia (wohl-bach-ee-uh) is a common type of bacteria found in insects. Approximately 6 in 10 of all types of insects, including butterflies, bees, and beetles, around the world have Wolbachia.

24.11.13 MERS (Middle East Respiratory Syndrome)

MERS is a respiratory disease caused by virus in Middle East countries. It is a respiratory disease caused by coronavirus (MERS-CoV). This virus was firstly reported in Saudi Arabia in 2012. The symptoms may appear from normal cold to severe acute respiratory syndrome (SARS) level. This disease is transmitted from animals to humans (zoonotic). Many scientists believe that this disease originated in bats and is then transmitted to camels. Mostly, this disease transfers through human-to-human infections. Camels are the main reservoir host for MERS infection.

Symptoms In mild infection: Fever, cough and shortness of breath are the normal symptoms. Sometimes, pneumonia is also found. Apart of these, gastrointestinal symptoms can also occur, like diarrhoea, etc. But in severe cases, it can lead to respiratory failure and cause death. Its mortality rate is approximately 36 per cent. Those people have weakened immune systems and suffer with chronic diseases like cancer, lung disease or diabetes; thus chance is more severe.

Mode of transmission Non-human to human transmission and human-to-human transmission.

Prevention and treatment It does not have any specific vaccine or treatment right now. Camel meat and camel-based products should be avoided. We should also try to make a distance with infected camel from our surroundings.

24.11.14 NIPAH Virus

According to WHO, the Nipah Virus infection is an emerging hooknoses, i.e., a disease transmitted from animals to humans. Nipah Virus belongs to a new genus termed *Henipavirus* (subfamily Paramyxovirinae). The fruit bats are natural host of the virus belonging to the family Pteropodidae. In 2004, many people were affected after the eating the date palm contaminated by infected fruit bats. Pigs can also act as intermediate hosts.

When was it First Reported?

It was first found in 1998 at Kampung Sungai Nipah village, Malaysia. The name of the virus has been taken from this village.

What are the Symptoms in Humans?

- The Nipah infection has the similar symptoms like influenza: fever, muscle pain and respiratory problems. Disorientation can also be caused due to inflammation of the brain.
- Late arrival of Encephalitis can also occur. Sometimes a person can have an asymptomatic infection, and become a carrier of Nipah where it doesn't show any symptoms
- Currently, there are no vaccines available for both human and animals. The supportive treatment is being given to the people infected by Nipah in form of intensive supportive care.
- According to WHO, the symptoms of nausea, vomiting and convulsions associated with the disease can be reduced by **ribavarin.** Individuals infected required to be hospitalised and isolated. Special care should be taken to prevent human-to-human transmission. To detect the virus quickly and to initiate appropriate control measures.

24.11.15 Kyasanur Forest Disease (KFD)

KFD is caused by **the Kyasanur Forest Disease Virus (KFDV).** The virus was identified in 1957 when it was isolated from a sick monkey from **the Kyasanur Forest.** Since then, between 400 and 500 humans cases per year have been reported. **Hard ticks *(Haemaphysalis spinigera)* are the reservoir** of the KFD virus and once infected, remain so for life. Rodents, shrews and monkeys are common hosts for KFDV after being bitten by an infected tick. KFDV can cause **epizootics** with high fatality in primates.

Transmission

- ***Transmission to humans may occur after a tick bite or contact with an infected animal***, most importantly a sick or recently dead monkey.
- The disease as of now is stated to be transmitted through monkeys. Large animals such as goats, cows and sheep may become infected with KFD but play a limited role in the transmission of the disease.
- ***These animals provide the blood meals for ticks*** and it is possible for infected animals with viremia to infect other ticks, but transmission of KFDV to humans from these larger animals is extremely

rare. Furthermore, **there is no evidence of disease transmission via the unpasteurised milk of any of these animals.**

Symptoms

- After an ***incubation period of 3–8 days***, the symptoms of KFD begin suddenly with ***chills, fever and headache. Severe muscle pain with vomiting, gastrointestinal symptoms and bleeding problems may occur 3–4 days after initial symptom onset.***
- ***Patients may experience abnormally low blood pressure, and low platelet, red blood cell and white blood cell counts.***
- After 1–2 weeks of symptoms, some patients recover without complication. However, the ***illness is biphasic*** for a subset of patients (10–20%) who experience a second wave of symptoms at the beginning of the third week. These symptoms include fever and signs of neurological manifestations, such as severe headache, mental disturbances, tremors and vision deficits.

Vulnerable Group

- People with recreational or occupational ***exposure to rural or outdoor settings (e.g., hunters, herders, forest workers, farmers)*** are potentially at risk for infection by contact with infected ticks.
- ***Seasonality*** is another important risk factor as more cases are reported ***during the dry season***, from November through June.

Diagnosis

- **Diagnosis** can be made in the early stage of illness by molecular detection by **PCR or virus isolation from blood.** Later, serologic testing using **enzyme-linked immunosorbent serologic assay (ELISA)** can be performed.

Prevention

- As per the doctors there is ***no specific treatment for KFD***, but early hospitalization and supportive therapy is important. ***Supportive therapy includes the maintenance of hydration and the usual precautions for patients with bleeding disorders.***
- A vaccine does exist for KFD and is used in endemic areas of India. Additional preventive measures include insect repellents and wearing protective clothing in areas where ticks are endemic.

24.11.16 Monkey Pox

Monkey Pox infection was first discovered in 1958 following two outbreaks of a pox-like disease in colonies of monkeys kept for research which led to the name 'monkey pox'. Human monkey pox was first identified in humans in 1970 in the Democratic Republic of the Congo and since then, cases kept on increasing across the region. Since 1970, human cases of monkey pox have been reported in 11 African countries: Benin, Cameroon, the Central African Republic, the Democratic Republic of the Congo, Gabon, Cote d'Ivoire, Liberia, Nigeria, the Republic of the Congo, Sierra Leone and South Sudan.

In 2003, the first monkey pox outbreak outside of Africa was in the United States of America and was linked to contact with infected pet prairie dogs. Recently, in May 2022, multiple cases of monkey pox were identified in several non-endemic countries. Studies are currently underway to further understand the epidemiology, sources of infection, and transmission patterns.

The WHO has already warned the world that the spread of cases could 'accelerate'. Recently, an outbreak of the monkey pox virus in Europe with cases also reported in the United States, Canada and Australia–has raised red flags worldwide.

UK health bodies, US health bodies as well as the WHO warn gay and bisexual men at more risk. It is important to understand the risk of infection 'is not limited to people who are sexually active or men who have sex with men, the WHO said, adding, "Anyone who has close physical contact with someone who is infectious is at risk." The identification in May 2022 of clusters of monkey pox cases in several non-endemic countries with no direct travel links to an endemic area is atypical.

Further investigations are underway to determine the likely source of infection and limit further onward spread.

Features of Monkey Pox Virus

- Monkey pox is a **viral zoonotic** (a virus transmitted to humans from animals) disease.
- The WHO describes Monkey pox as a 'self-limited disease with symptoms lasting from two to four weeks'.
- Its symptoms are similar to those seen in smallpox (a related orthopoxvirus infection) patients, although it is clinically less severe.

- Smallpox was a serious infectious disease caused by the variola virus and its transmission was rapid and most of the time fatal, as about 30% of the patients died.
- The last case of naturally acquired smallpox occurred in 1977, and in 1980 smallpox was declared to have been eradicated worldwide after a global campaign of vaccination and containment.
- It was found that smallpox vaccination also protected against monkey pox in the west and central Africa; thus now unvaccinated populations are also more susceptible to monkey pox virus infection.

Monkey pox is caused by the Monkey pox virus which is an enveloped **double-stranded DNA virus** that belongs to the *Orthopoxvirus* genus of the *Poxviridae* family.

There are two distinct genetic variants of the monkey pox virus:

1. **The central African (Congo Basin) strain:** up to 10% mortality

The West African strain: 1% fatality rate

The geographical division between the two strains is Cameroon, the only country where both virus strains have been found. Various animal hosts include rope squirrels, tree squirrels, Gambian pouched rats, dormice, non-human primates, and other species.

Monkey pox symptoms include fever, myalgia (muscle aches), intense headaches, lymphadenopathy (swollen lymph nodes), skin rashes or lesions, intense asthenia (lack of energy), and back pain.

The incubation period is generally between 6 to 13 days, but can range between 5 to 21 days. Complications of monkey pox can include secondary infections, bronchopneumonia, sepsis, encephalitis, and infection of the cornea with ensuing loss of vision.

Transmission: Via Animal

Animal-to-human (zoonotic) transmission can occur from direct contact with the blood, bodily fluids, or cutaneous or mucosal lesions of infected animals.

Transmission: Via Human

Human-to-human transmission can result from close contact with respiratory secretions, skin lesions of an infected person, or recently contaminated objects. Transmission via droplet respiratory particles usually requires prolonged face-to-face contact. Transmission can also occur via the placenta from mother to fetus (which can lead to congenital monkey pox) or during close contact during and after birth.

Diagnosis

- Polymerase chain reaction (PCR) is the preferred laboratory test, given its accuracy and sensitivity.
- For this, optimal diagnostic samples for monkey pox are from skin lesions and these samples must be stored in a dry, sterile tube and kept cold.
- Biopsy is also an option.

Vaccination

- Vaccination against smallpox was demonstrated through several observational studies to be about 85 per cent effective in preventing monkey pox.
- Evidence of prior vaccination against smallpox can usually be found as a scar on the upper arm.
- Presently, the original (first-generation) smallpox vaccines are no longer available to the general public.
- Some laboratory personnel or health workers have been given a more recent version of smallpox vaccine to protect them in the event of exposure to orthopoxviruses in the workplace.
- A new vaccine based on a modified attenuated vaccinia virus (Ankara strain) was approved for the prevention of monkey pox in 2019. This is a two-dose vaccine for which availability remains limited.

24.11.17 Adenovirus

Adenoviruses are a group of common viruses that infect the lining of your eyes, airways and lungs, intestines, urinary tract, and nervous system. They are common causes of fever, coughs, sore throats, diarrhoea, and pink eye. Infections happen in children more often than in adults, but anyone can get them. The infections usually cause only mild symptoms and get better on their own in a few days. But they can be more serious in people with weak immune systems, especially children.

How Adenoviruses Spread?

These viruses are common in places with large groups of kids, such as day care centres, schools and summer camps. They are very contagious. They can spread when someone who is infected coughs or sneezes. Droplets containing the virus fly into the air and land on surfaces.

Symptoms: Each type of adenovirus can affect differently:

- Bronchitis: Cough, runny nose, fever, chills
- **Colds and other respiratory infections**: Stuffy and runny nose, cough, sore throat, and swollen glands
- **Ear infection**: Ear pain, irritability, fever
- Pink eye **(conjunctivitis):** Red eyes, discharge from your eyes, tearing, feeling like there is something in your eye
- **Pneumonia:** Fever, cough, trouble breathing
- Stomach **and intestinal infections:** Diarrhoea, vomiting, headache, fever, stomach cramps
- **Swelling of the brain and spinal cord (meningitis** and **encephalitis):** Headache, fever, stiff neck, nausea, and vomiting (this is rare)
- **Urinary tract infections:** Burning and pain while urinating, frequent need to go to the washroom, blood in your urine

Call the doctor right away if your child has any of these more serious symptoms:

- Trouble breathing
- Swelling around their eyes
- Fever that does not go away after a few days
- Signs of dehydration, such as few tears or less wet diapers

Treatment

Antibiotics will not help adenovirus infections because these drugs only kill bacteria. Children often get over the illness on their own within a few days. Some infections, like pink eye or pneumonia, can last for a week or more.

Kids with a weak immune system may need treatment in the hospital to help them recover.

ADENOVIRUSES vs RETROVIRUSES

- Adenoviruses are double-stranded DNA genomes. Retroviruses are single-stranded RNA animal viruses that employ a double-stranded DNA intermediate for replication.
- Common cold is a symptom of adenovirus. The retrovirus known as human immunodeficiency virus (HIV) causes acquired immunodeficiency syndrome (AIDS) in humans.

24.12 SUPERBUG ISSUES

According to British dictionary, Superbug is defined as, *'An infective microorganism that has become resistant to antibiotics'.*

Alexander Fleming has developed the world's first antibiotic Penicillin in 1928 from a fungi, *Penicillium notatum.* For this contribution, he got the Nobel Prize. But, the bacteria were already fighting back after many years due to resistance against these antibiotic. After some time, scientists also got a strain of *Staphylococcus aureus (S. aureus)* bacteria that became resistant against penicillin, due to genetic mutation.

Some bacteria can and have developed resistance to most of, if not all, the antibiotics that are being used against them. *Staphylococcus aureus is also another bacteria* that have become resistant to methicillin and many other antibiotics *(MRSA –* **methicillin resistant** *Staphylococcus aureus).* Recently, even MRSA strains have developed a resistance to vancomycin, that is a powerful antibiotic with frequent unpleasant side effects. Vancomycin was used for over 30 years as an antibiotic of last resort before resistance to it emerged.

24.13 DRUG-RESISTANT TUBERCULOSIS (TB) – MDR, MDR+, XDR, XDR+

There are different types of drug-resistant tuberculosis, namely:

MDR TB and XDR TB

Rifampicin and isoniazid are the first level of medicine against TB bacteria. If these bacteria become resistant to this medicine, they are called as MDR (multi-drug resistant) TB level. XDR TB (extensively drug-resistant TB) is the next level of resistance, where bacteria become resistant to at least rifampicin and Isoniazid and additionally to fluoroquinolones, kanamycin or capreomycin andamikacin (these all are second line of tuberculosis drugs). Standard TB treatment is minimum for six months but in the case of MDR TB and XDR TB, they take two years or more. This treatment require more toxic and much more expensive drugs.

'MDR(+) plus' and XDR(+) plus

If first and second line of drug resistance case generate so it called as MDR+ case where patients not possible to be treated. If this case will reach up to totally drug resistant level so called as **'XDR (+) plus' TB.**

NEW ANTI-TUBERCULOSIS DRUG

US Food and Drug Administration (FDA) has approved a new drug **Pretomanid** for treating drug resistant tuberculosis – multidrug-resistant TB (MDR-TB) and extensively drug-resistant TB (XDR-TB).

Key Facts

- **Pretomanid is only the third new anti-TB drug approved for use by FDA in more than 40 years.**
- Pretomanid will be part of the three-drug regimen for drug approval by the European Medicines Agency (EMA).
- **The duration of treatment for drug-resistant TB can be drastically cut** from 18 to 24 months to just six-nine months when pretomanid drug is used along with two already approved drugs – bedaquiline and linezolid.
- The all-oral, **three-drug regimen can also vastly improve the treatment success rate** and potentially decrease the number of deaths due to better adherence to treatment.

24.14 NEW DELHI METALLO-BETA-LACTAMASE (NDM-1)

NDM-1 is an enzyme, which makes bacteria resistant to a carbapeneme-family antibiotics. It is also a 'superbug' case. First case of NDM-1 came to limelight in December 2009 in New Delhi, where a patient was suffering from an infection caused by *Klebsiella pneumoniae.* Later on, it was detected in many nations – United Kingdom, Pakistan, United States, Canada and Japan. These all are Gram positive (+ve) bacteria like *Escherichia coli (E.coli)* and *Klebsiella pneumoniae,* got antibiotic resistance due to presence of NDM-1 gene those synthesis NDM-1 enzyme and can spread from one strain of the bacteria to another through horizontal gene transfer. This incidence was in news in India during 2010–2011.

24.15 FIXED DOSE COMBINATION (FDC) DRUGS

An FDC is a blend of two or more active drug ingredients in a fixed ratio of doses. According to US healthcare provider IMS Health, **almost half the drugs sold in India in 2014 were FDC, making it a world leader in combination drugs.**

With immediate effect **the manufacture, sale or distribution of 328 fixed dose combination (FDC) drugs for human use** has been banned by the Government.

The **health ministry's ban on FDCs includes pain-killers, anti-diabetic, respiratory and gastrointestinal medicines, covering 6,000 brands.**

What necessitated this?

The expert panel probing the efficacy of 349 banned FDCs, after considering these drugs **'irrational'**, cited safety issues and lack of therapeutic justification, and has given recommendation to continue the ban. There were findings that many FDCs were formulated without due attentiveness, **with dosing mismatches that could result in toxicity.**

Why are they popular in India?

- FDC is popular in India due to advantages such as **increased efficacy, better compliance, reduced cost and simpler logistics of distribution.**
- In treating infectious diseases particularly like **HIV, malaria and tuberculosis; FDC plays important role,** where giving multiple antimicrobial agents is the norm. FDCs are also useful for chronic conditions especially, when multiple disorders co-exist.

Is there a flipside to FDCs?

- Given that **much data is not available on drug-drug interaction and side-effects in FDC,** India's system for collecting data for problematic drug reactions is weak. **When multiple drugs from the same therapeutic group, like antibiotics, are clubbed together, drug resistance may be the result.**
- A lot of FDCs sold in India are unapproved because of lack of coordination between state and central regulators. **A study published in the journal of Public Library of Science (PLOS) in May, 2012 found that over 70% of non-steroidal anti-inflammatory drug (NSAID) combinations, which are used as painkillers, were being marketed in India without central government approval.**

CENTRAL DRUGS STANDARD CONTROL ORGANIZATION (CDSCO)

The Central Drugs Standard Control Organization (CDSCO) under **Directorate General of Health Services, Ministry of Health & Family Welfare, Government of India is the National Regulatory Authority (NRA) of India. Under the Drugs and Cosmetics Act,** CDSCO have responsibility of approval of New Drugs, Conduct of Clinical Trials, laying down the standards for Drugs, control over the quality of imported Drugs in the country and coordination of the activities of State Drug Control Organizations by providing expert advice with a view of bring about the uniformity in the enforcement of the Drugs and Cosmetics Act.

Further CDSCO along with its state counterparts **is jointly responsible for grant of licences of certain specialised categories of critical drugs.**

24.16 GENERIC DRUGS/GENERIC MEDICINE

Generic medicines are **unbranded medicines which are equally safe and having the same efficacy as that of branded medicines** in terms of their therapeutic value. The prices of generic medicines are much cheaper than their branded equivalent.

Why are they cheaper?

- Since the manufacture of these generic drugs do not involve a repeat of the extensive clinical trials to prove their safety and efficacy, it costs less to develop them. Generic drugs are, therefore, cheaper.
- Because the compounds in the generic versions have the same molecular structure as the brand name version, **their quality is essentially the same.**

Why aren't generic drugs more popular?

- **Lack of awareness about them.**
- Since they are cheap, **people who can afford branded drugs don't buy them believing them to be of inferior quality.** Chemists have to hand out exactly what's written on the prescription and most doctors except in government hospitals don't hand out generic drugs.
- Also, private doctors never hand out generic drugs because there are no kickbacks or incentives involved from pharma companies.
- The government or specifically the government's Department of Pharmaceuticals is also to blame for the lack of awareness.

However, there are three fundamental areas of concern

- **Efficacy of Indian-made drugs:** Oftentimes, such drugs have been found to contain less than the required amount of active pharmaceutical ingredient (API), rendering them ineffective.
- **Lack of data integrity:** The poorly managed documentation practices of Indian generic firms featured as the primary criticism flagged by foreign regulatory authorities. The lack of reliable and complete data on the test results of specific drug batches, along with inconsistencies in the records presented, meant that inspection and verification of drug quality was extremely difficult.
- **Hygiene standards of the manufacturing plants:** Individuals suffering from illness are especially susceptible to infections, and inspections of generic drug plants reveal pest infestations and dilapidated infrastructure.

JAN AUSHADHI SUGAM APP

- **Union Ministry for Chemicals and Fertilisers** has launched a mobile application 'Jan Aushadhi Sugam'.
- The application **aims to enable people to search Jan Aushadhi generic medicines and the stores at the tip of their fingers.**
- It will also help analyse product comparison of Generic vs Branded medicine in form of MRP and overall savings.

24.16.1 Pradhan Mantri Bhartiya Janaushadhi Pariyojana (PMBJP)

Pradhan Mantri Bhartiya Janaushadhi Pariyojana is **a campaign launched by the Department of Pharmaceuticals, Govt. of India, to provide quality medicines at affordable prices** to the masses through special kendras known as **Pradhan Mantri Bhartiya Jan Aushadhi Kendra.** This have been **set up to provide generic drugs,** which are available at lesser prices but are equivalent in quality and efficacy as expensive branded drugs. **Bureau of Pharma PSUs of India (BPPI)** is the implementing agency of PMBJP. BPPI (Bureau of

Pharma Public Sector Undertakings of India) has been established under the Department of Pharmaceuticals, Govt. of India, with the support of all the CPSUs.

PRADHAN MANTRI JAN-AUSHADHI YOJANA

Initially **launched in 2008**, the scheme was **rechristened in 2015**. The government has set a target to increase the number of **Pradhan Mantri Bhartiya Janaushadhi Kendras (PMBJKs)** to 10,000 by March 2024.

Salient Features of the Scheme

- Ensure access to quality medicines.
- Extend coverage of quality generic medicines so as to reduce the out-of-pocket expenditure on medicines and thereby redefine the unit cost of treatment per person.
- Create awareness about generic medicines through education and publicity so that quality is not synonymous with only high price.
- A public programme involving Government, PSUs, Private Sector, NGO, Societies, Cooperative Bodies and other Institutions.
- Create demand for generic medicines by improving access to better healthcare through low treatment cost and easy availability wherever needed in all therapeutic categories.

DRUGS AND COSMETIC RULES, 1945

The Central Government is considering amendments **to the Drugs and Cosmetic Rules, 1945** to ensure that registered medical practitioners dispense only generic medicines.

Background

- A proposal was received by the **Central Drugs Standard Control Organisation (CDSCO)** committee wherein **the Drugs Consultative Committee (DCC)** was apprised that registered medical practitioners can supply different categories of medicines including vaccines to their patients under the exemption provided, with certain conditions, under **Schedule K of the Drugs and Cosmetics Rules, 1945.** As of now there are no specified types of medicines which can be supplied by doctors to their patients.
- It is now proposed that **registered medical practitioners shall supply generic medicines only** and physicians samples shall be supplied free of cost.

24.17 BIOSIMILAR MEDICINE

It is ***a biologic medical product*** that is almost ***an identical copy of an original product that is manufactured by a different company.*** They are ***officially approved versions of original 'innovator' products and can be manufactured when the original product's patent expires. Reference to the innovator product*** is an integral component of the approval.

Characteristics

- Biological medicines ***contain active substances from a biological source,*** such as living cells or organisms.
- Most biological medicines in current clinical use ***contain active substances made of proteins.***

Difference between Biosimilars and Generics

- Biosimilars involve developing equivalent of ***biological entity,*** while generics involve developing equivalent of a ***chemical entity*** – the Active Pharmaceutical Ingredient.
- **Cost:** Generic drugs are chemically identical to the original branded drug and, as such, cost significantly less because they don't require much testing. Because biosimilars are made from living organisms, though, and don't contain identical ingredients to their name-brand counterparts, they still require some testing. So, they cost more than generics, but less than the branded biologic.

Need of the Hour

- Biosimilars industry can act as ***a springboard for the pharma companies to innovate, excel and earn profit and the same needs to be promoted at the earliest.***
- We need ***to increase access through affordable pricing and some of the drugs need to be under price control.***
- Governments can support growth in production of complex generics and biosimilars by clarifying ***the regulatory framework*** for them, which is still evolving in many countries.

First Biosimilar Medicine – Trastuzumab

WHO prequalifies ***first biosimilar medicine – trastuzumab,*** to increase worldwide access to life-saving breast cancer treatment. ***Trastuzumab – a monoclonal antibody*** – was included in ***the WHO Essential***

Medicines List in 2015 as an essential treatment for about 20% of breast cancers. Breast cancer is the most common form of cancer in women. 2.1 million women contracted breast cancer in 2018. 630,000 of them died from the disease, many because of late diagnosis and lack of access to affordable treatment.

24.18 BIOFILM

An association of micro-organisms in which microbial cells adhere to each other on living or non-living surfaces within a self-produced matrix of extracellular polymeric substance is called biofilm.

- Its formation is a multi-step process starting with attachment to a surface then formation of micro-colony that leads to the formation of three-dimensional structure and finally ending with maturation followed by detachment.
- During its formation many species of bacteria are able to communicate with one another through a specific mechanism called quorum sensing, which is a system of stimulus to co-ordinate different gene expressions.
- Bacterial biofilm is less accessible to antibiotics and the human immune system and thus poses a big threat to public health because of its involvement in a variety of infectious diseases.
- Biofilms may form on living or non-living surfaces and can be prevalent in natural, industrial and hospital settings.
- Biofilms can be present on the teeth of most animals as dental plaque, where they may cause tooth decay and gum disease.

A combination of several pathogens can synergistically interact to form biofilms in the food industry. In food-processing environments, bacteria are able to exist as multispecies biofilms, from where both spoilage and pathogenic bacteria can contaminate food. For instance, in the fishing industry, fresh fish products can suffer from biofilm formation by mixed pathogenic species (*Aeromonas hydrophila*, *L. monocytogenes*, *S. enterica*, or *Vibrio spp.*), which can imply significant health and economic issues. Synergistic interactions have been observed in a fresh-cut produce processing plant, where *E. coli* interacted with *Burkholderia caryophylli* and *Ralstonia insidiosa* to form mixed biofilms.

PART C: DIFFERENT IMMUNISATION PROGRAMMES IN INDIA

24.19 NATIONAL VECTOR BORNE DISEASE CONTROL PROGRAMME (NVBDCP)

The National Vector Borne Disease Control Programme (NVBDCP) is a comprehensive programme for prevention and control of vector-borne diseases namely **Malaria, Filaria, Kala-azar, Japanese Encephalitis (JE), Dengue and Chikungunya**, which are covered under the overall umbrella of NRHM. Directorate of National Vector Borne Disease Control Programme (NVBDCP) is the central nodal agency for the prevention and control of vector-borne diseases.

24.19.1 National Anti-Malaria Programme

Malaria is a complex mosquito-borne infectious disease caused by a eukaryotic protist of the genus Plasmodium. It varies widely in epidemiology and clinical manifestation in different parts of the world. In India, Malaria is caused by *Plasmodium falciparum* or *Plasmodium vivax*, transmitted by nine major species of the female anopheles mosquitoes.

Malaria continues to pose a major public health threat in different parts of the country, particularly due to *Plasmodium falciparium*, as it is sometimes prone to complications and death, if not treated early. The major vector mosquito for rural malaria, viz., *Anopheles culicifacies*, is distributed all over the country and breeds in clean groundwater collections. Some of the vector species also breed in forest areas, mangroves, lagoons, etc., even in those with organic pollutants.

About 80 per cent of malaria burden is in Northeastern (NE) states, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, Andhra Pradesh, Maharashtra, Gujarat, Rajasthan, West Bengal and Karnataka. The focus is on empowering grass-root workers in diagnosing and treating malaria cases even in remote and inaccessible areas by scaling-up the availability of bivalent Rapid Diagnostic Kits (RDK) and Artemisinin-based Combination Therapy (ACT). There is a need to give thrust for prevention/control of malaria (and other VBD also) in urban areas under the Urban Malaria Scheme, which is presently implemented in only 131 towns/cities. These efforts, coupled with integrated vector control strategies including distribution of Long Lasting Insecticide Treated Nets (LLIN) in endemic areas, will greatly reduce the malaria morbidity and mortality. Bi-valant Rapid Diagnostic Kit for improving diagnostic facilities for both types of malaria (*Plasmodium falciparum* and *Plasmodium vivax*) in difficult and inaccessible areas has been introduced in the programme. Performance-based incentive for ASHAs in endemic areas for Malaria and Kala-azar has been introduced in India.

9.2 Japanese Encephalitis (JE) Control Programme

Japanese Encephalitis is a zoonotic disease, which is transmitted by vector mosquito, mainly belonging to *Culex vishnui* group. The transmission cycle is maintained in the nature by animal reservoirs of JE virus like pigs and water birds. Man is the dead-end host, i.e., JE is not transmitted from one infected person to other. Outbreaks are common in those areas where there is close interaction between animals/birds and human beings. The vectors of JE breed in large water bodies such as paddy fields. AES is emerging as a serious public health challenge. Given its complex etiology, medical complications and after-effects of illness, effort is on to develop a multi-pronged strategy, including safe water, sanitation, nutrition, community education, medical attention and rehabilitation to address the problem. The disease is endemic in 14 states; of which, Assam, Bihar, Haryana and Uttar Pradesh have been reporting outbreaks.

24.20 COMMUNICABLE DISEASES CONTROL PROGRAMME

24.20.1 National AIDS Control Programme (NACP)

Human Immunodeficiency Virus (HIV) is retro-virus. It is also known as human T-lymphotropic virus-III (HTLV-III), lymphadenopathy-associated virus (LAV) and AIDS-associated retrovirus (ARV). Transmission involves anal, vaginal or oral sex, blood transfusion, contaminated hypodermic needles, exchange between mother and baby during pregnancy, childbirth, breastfeeding or other exposure to one of the above bodily fluids.

Objectives

1. Suppressing the spread of HIV infection in India.
2. Strengthening India's capacity to respond towards HIV/AIDS on a long-term basis.

To reflect the extreme urgency with which HIV prevention and control must be pursued in India, the AIDS-II project of the National AIDS Control Programme is operational across all States and Union Territories. Moreover, a Centrally Sponsored Scheme with 100 per cent financial assistance from the Government of India direct the State AIDS Control Societies and certain selected Municipal Corporations/AIDS Control Societies.

Realising the potential threat due to HIV/AIDS, the world's AIDS day is celebrated on 1 December every year to spread the awareness about life-threatening diseases.

24.20.2 National Leprosy Eradication Programme (NLEP)

Leprosy is a chronic disease caused by a bacillus, *Mycobacterium leprae.* Official figures (WHO) show that more than 2,13,000 people, mainly in Asia and Africa, are infected, with approximately 2,49,000 new cases reported in 2008. *M. leprae* multiplies very slowly and the incubation period of the disease is about five years. Symptoms can take as long as 20 years to appear. Leprosy is not highly infectious. It is transmitted via droplets, from the nose and mouth, during close and frequent contacts with untreated cases. Untreated, leprosy can cause progressive and permanent damage to the skin, nerves, limbs and eyes. Early diagnosis and treatment with multi-drug therapy (MDT) remain the key elements in eliminating the disease as a public health concern.

Objectives

1. Early detection that can be achieved through active surveillance by the trained health workers;
2. Regular treatment of cases by provisions of Multi-Drug Therapy (MDT) at fixed incentres or a nearby village with moderate to low endemic areas/district;

3. Intensifying health education and public awareness campaigns for the removal of social stigma attached to the disease;
4. Appropriate medical rehabilitation and the leprosy ulcer care services.

24.20.3 Revised National Tuberculosis Control Programme (RNTCP)

In 1962, the National TB Control Programme was started with the aim to detect cases earliest and treat them. The District Tuberculosis Centre (DTC) and the Primary Health Institutions together assist in implementation of the programme, in the district. The state-level organisations support District Tuberculosis Programme (DTP) for the coordination and supervision of the programme. In 1993, the Revised National Tuberculosis Control Programme (RNTCP) that is based on the DOTS strategy began as a pilot project. It was launched as a national programme in 1997; however, rapid RNTCP expansion began in late 1998.

NIKSHAY, a web-based reporting for TB programme, has been another notable achievement that was initiated in 2012. It has enabled capture as well as transfer of individual patient data from country's remotest health institutions.

Objectives

- Pursuing quality DOTS expansion and enhancement, by improving case finding and cure through an effective patient-centred approach so as to reach all patients, especially the poor.
- Addressing TB-HIV, MDR-TB and other challenges, through scaling up of TB-HIV joint activities, DOTS Plus, and other such relevant approaches.
- Contributing to health system strengthening, through collaboration with other health programmes and general services.
- Involving all health care providers-nongovernmental and private, public by scaling up approaches that are based on a public-private mix (PPM). This can ensure adherence to the international standards of TB care.
- Engaging people with TB, and affected communities to demand, and contribute towards effective care. This will involve scaling-up of the community TB care; communication and social mobilisation and creating demand through context-specific advocacy.
- Enabling and promoting research for the development of new drugs, vaccines and diagnostics. Operational Research will also be required to improve programme performance.

24.20.4 Pulse Polio Programme

Following World Health Assembly resolution in 1988, with the global initiative of eradication of polio in the year 1998, the Pulse Polio Immunisation Programme was launched in 1995, in India. Under this programme, children in the age group of 0–5 years are administered polio drops during the National and Sub-national immunisation rounds (in high risk areas) every year. As estimated, about 172 million children are immunised during each of the National Immunisation Day (NID).

On 24 February 2012, the WHO removed India from the list of the countries with active endemic wild poliovirus transmission.

Objective

- Achieving 100 per cent coverage under Oral Polio Vaccine. It aimed to immunise children through improved social mobilisation, plan mop-up operations in the areas where poliovirus has almost disappeared and thus maintain high level of morale among the public.

Note: Two types of vaccine protecting against polio are inactivated poliovirus vaccine (IPV) and oral poliovirus vaccine (OPV). The IPV is given as an injection in the arm or leg, according to patient's age. The polio vaccine may be given simultaneously as other vaccines. Most people need to get polio vaccine during their early age. IPV is given to children in 4 doses at these ages: 2 months, 4 months, 6–18 months, and the booster dose at 4–6 years.

The first polio vaccine was the inactivated polio vaccine and was developed by Jonas Salk and came into use in 1955. While the oral polio vaccine was developed by Albert Sabin and in 1961 came into commercial use. In the US, OPV has not been used since 2000; however, it is still used in several parts of the world.

24.21 NATIONAL NUTRITIONAL PROGRAMMES

24.21.1 Mid-Day Meal Programme

The Mid-day Meal Scheme involves provision of lunch at free of cost to school children on all working days. Its key objectives include: Protecting children from classroom hunger; Increasing school enrolment and attendance; Improved socialisation among children belonging to all castes; and Addressing malnutrition, and social empowerment through provision of employment to women.

The scheme has a long history, especially in Tamil Nadu and Gujarat, and has been expanded to all parts of India after a landmark direction by the Supreme Court of India on 28 November 2001.

Tamil Nadu was the first state to implement this programme.

Objectives

- Improvement in the nutritional status of children in classes I–VIII in Government, Local Body and Government-aided schools, as well as EGS and AIE centres.
- Encouraging poor children, who belong to disadvantaged sections, to attend school more regularly and help them in concentrating on classroom activities.
- Providing nutritional support to the children of primary stage in drought-affected areas.

24.22 OTHERS

24.22.1 Universal Immunisation Programme (UIP)

Universal Immunisation Programme is the name given to the vaccination programme, which was launched by the Government of India in 1985. In 1992, it became a part of Child Survival and Safe Motherhood Programme and is currently serving as one of the key areas under the National Rural Health Mission (NRHM) since 2005.

The programme consists of vaccination for 9 diseases: In 2007, addition of TB, Diphtheria, Pertussis/(whooping cough), Poliomyelitis, Diarrhoea, Japanese Encephalitis, Measles, Tetanus, Hepatitis B and Pneumonia. Hepatitis B was done to the UIP. Therefore, UIP has nine vaccine-preventable diseases under this programme.

In 2014, it was announced that four vaccines would be added to the programme, namely Rotavirus, Rubella and Japanese Encephalitis, as well as Injectable Polio Vaccine.

24.22.2 National Rural Health Mission

The National Rural Health Mission (NRHM) was launched by the Hon'ble Prime Minister on **12th April 2005**, to provide accessible, affordable and quality health care to the rural population, especially the vulnerable groups. The key features in order to achieve the goals of the Mission include making the public health delivery system fully functional and accountable to the community, human resources management, community involvement, decentralisation, rigorous monitoring & evaluation against standards, the convergence of health and related programmes from village level upwards, innovations and flexible financing and also interventions for improving the health indicators.

Janani Suraksha Yojana

Janani Suraksha Yojana (JSY) is a safe motherhood intervention under the National Rural Health Mission (NHM), launched in 2005.

The scheme is under implementation in all states and Union Territories (UTs).

- Its objective is to reduce maternal and infant mortality among poor pregnant women.
- Its aim to promote institutional delivery among poor pregnant women.
- Its objective includes providing public health facilities to sick infants up to one year of age.

Target Group and Benefits

- The program primarily targets economically disadvantaged expectant women, with particular emphasis on states that have low rates of institutional childbirth. These states are Uttar Pradesh, Uttarakhand, Bihar, Jharkhand, Madhya Pradesh, Chhattisgarh, Assam, Rajasthan, Odisha, and Jammu and Kashmir, collectively referred to as Low Performing States (LPS). The remaining states are categorized as High Performing States (HPS).
- The program also offers performance-driven incentives to female healthcare volunteers referred to as ASHA (Accredited Social Health Activist) to encourage institutional delivery among expectant mothers. Through this program, eligible pregnant women receive direct financial assistance, known as JSY benefit, deposited into their personal bank accounts. The cash entitlement for various categories of mothers is as outlined below:

Cash Assistance for Institutional Delivery (in Rs)

Category	Rural Area		Total	Urban Area		Total
	Mother's package	ASHA's package*		Mother's package	ASHA's package**	
LPS	1400	600	2000	1000	400	1400
HPS	700	600	1300	600	400	1000

*ASHA package of ₹600 in rural areas include ₹300 for ANC component and ₹300 for facilitating institutional delivery.

**ASHA package of ₹400 in urban areas include ₹200 for ANC component and ₹200 for facilitating institutional delivery.

Source: nhm.gov.in (as accessed in July 2023)

24.22.3 National Nutrition Mission

National Nutrition Mission was introduced by the Ministry of Women and Child Development, Government of India, to create awareness relating to malnutrition among pregnant women and lactating mothers through reduction of the incidence of anaemia among young children, adolescent girls and women.

In *Global Nutrition Report 2016,* India's progress was slow in addressing chronic malnutrition, manifest in stunting (low weight for age), wasting (low weight for height), micronutrient deficiencies and overweight. Even Bangladesh and Nepal are marginally better than India. As per the latest Global Nutrition Report 2022, the situation is no better. Barring the war-torn Afghanistan, India has performed worse than all the countries in the South Asian region in the Global Hunger Index 2022. It has ranked 107 out of 121 countries. India ranked 101 out of 116 countries in the Global Hunger Index (GHI) 2021.

The poor nutritional status of adolescent girls, combined with child marriage and multiple pregnancies even before becoming an adult is another reason that leads to 30 per cent of all children being born with low birth-weight.

Under-nutrition (at both level of malnutrition and micronutrient deficiencies) among nearly 70 per cent of school-going children challenges the capacity for physical growth and cognitive development.

The past decade has seen a steady build-up of momentum around nutrition with the setting up of UN; the World Health Assembly adoption (in 2012) of the 2025 global targets for maternal, infant and development goals, which centre-stage the ending of all forms of malnutrition for all people by 2030, to name a few. India's progress clearly lags behind which is needed to eliminate malnutrition by 2030.

24.22.4 Mission Indradhanush

Mission Indradhanush was launched by the Ministry of Health and Family Welfare, Government of India, on 25 December 2014.

Objective

Mission Indradhanush aims to cover all those children under the age of 2 years by 2020, who are either unvaccinated, or are partially vaccinated against vaccine-preventable diseases. It will also cover all pregnant women against seven preventable diseases: **Diptheria, Hepatitis B, Whooping cough, Tetanus, Poliomyelitis, Tuberculosis** and **Measles.** In some states, vaccination against **Japanese Encephalitis and Haemophilus Influenza Type B are** also included. In 2016, **Rubella, Japanese Encephalitis, Injectable Polio Vaccine** and **Rota-virus** vaccine also become part of this mission. **Pneumonia** vaccine was also added to this mission in 2017.

Intensified Mission Indradhanush (IMI)

To further intensify the immunisation programme, the government launched the Intensified Mission Indradhanush (IMI) on October 8, 2017.

Key Facts

- Through this programme, Government of India aims to reach each and every child up to two years of age and all those pregnant women who have been left uncovered under the routine immunisation programme/UIP.
- Intensified Mission Indradhanush will cover low performing areas in the selected districts (high priority districts) and urban areas. Special attention will be given to unserved/low coverage pockets in sub-centre and urban slums with migratory population.

Intensified Mission Indradhanush 2.0 (IMI 2.0)

To ensure that not a single child in the country misses out on vaccination, the government launched the *'Intensified Mission Indradhanush 2.0'* in October 2019, with ***a special focus on improving coverage in areas with 'low' immunisation.***

Key Facts

- Through 'IMI 2.0', the health ministry aims to reach each and every child below the age of two years and all pregnant women still uncovered/partially covered in 271 districts of the country and 652 blocks of Uttar Pradesh and Bihar.
- IMI 2.0 will include four rounds of vaccination, with each round involving a seven-day immunisation drive to be conducted each month.
- The IMI programme is supported by 12 ministries and departments and is being monitored by the cabinet secretary at the national level.

Existing Gaps

The current national full immunisation coverage rate stands at 87 per cent. According to government data, 260 lakh children are born every year and an estimated 31 lakh out of them would not receive complete rounds of vaccination in the first year of their life due to various reasons.

Mission Indradhanush 3.0: To Focus on Children, Women Who Missed Vaccines

Union Health Minister launched Intensified Mission Indradhanush (IMI) 3.0 with a focus on children and pregnant women who missed their vaccine doses during the COVID-19 pandemic.

Mission Indradhanush (IMI) 3.0

- It is a campaign aimed to reach those children and pregnant women who have been missed out or been left out of the Routine Immunisation Programme.
- This is aimed to accelerate the full immunisation of children and pregnant women through a mission mode intervention.
- It is being conducted in pre-identified 250 districts/urban areas across 29 States/UTs in the country.
- Beneficiaries from migration areas and hard to reach areas will be targeted as they may have missed their vaccine doses during the pandemic.
- **Classification of districts:** As per the guidelines released for IMI 3.0, the districts have been classified to reflect 313 low risk, 152 medium risk and 250 high risk districts.

24.22.5 Ayushman Bharat

Government of India has introduced a **National Health Protection Scheme,** which will **cover over 10 crore poor vulnerable families (around 50 crore beneficiaries) providing coverage of up to 5 lakh (per family per year) for secondary and tertiary care hospitalisation. It will subsume the on-going centrally sponsored schemes – Rashtriya Swasthya Bima Yojana (RSBY)** and the **Senior Citizen Health Insurance Scheme (SCHIS). This scheme is named as Ayushman Bharat.**

Highlights of the Scheme

- **Coverage:** This scheme will have the benefit cover of ₹5 lakh per family per year. **There will be no cap on family size and age in the scheme** to ensure that no one is left out. It will **also include pre- and post-hospitalisation expenses.**
- **Target: More than 10 crore families belonging to poor and vulnerable population based on SECC database** will be the targeted beneficiaries. Benefits of the scheme are portable across the country and a **beneficiary covered under the scheme will be allowed to take cashless benefits from any public/private empanelled hospitals across the country.**
- **Role of state governments:** State governments can expand AB-NHPM both horizontally and vertically. **States will be free to choose the modalities for implementation.** Implementation can be done through insurance company or directly through Trust/Society or a mixed model.
- **Council:** For guiding in policy directions and nurturing coordination between Centre and States, there is provision for setting up **Ayushman Bharat National Health Protection Mission Council (AB-NHPMC)** at apex level Chaired by Union Health and Family Welfare Minister.

Prime Minister Narendra Modi in 2018 rolled out the Centre's flagship scheme – **Pradhan Mantri Jan Arogya Abhiyaan, also known as Ayushman Bharat or the National Health Protection Mission (AB-NHPM).**

Significance of the Project

- It is one of the **world's largest health scheme.**
- **Meant to help the poor and the economically deprived; the scheme will be available for 10.74 crore beneficiary families and about 50 crore Indian citizens.**
- According to health ministry officials, the 71st **round of National Sample Survey Office (NSSO) says that 85.9% of rural households and 82% of urban households have no access to healthcare insurance/assurance.**

India eradicated many diseases in recent past – Small pox, Rinderpest, Polio, Yaws, Maternal and Neonatal Tetanus.

Smallpox: It is a viral disease eradicated in 1980.

Rinderpest: It affects cattle and ruminants. India became free from Rinderpest in October 2010.

Polio: In March 2014, South-East Asia Region was certified as polio-free. For the last time, it was recorded in West Bengal in 2011.

Yaws: It is a bacterial infection, which mostly affects tribal population. It targets skin, bones and joints and was eliminated from India in September 2006 but certified by WHO and UNICEF in July 2016.

Maternal and Neonatal Tetanus (MNT): This disease spreads in unhygienic circumstances where mothers and babies become vulnerable to MNT and die. In August 2015, this disease was completely eliminated.

Ayushman Bharat Digital Mission

- Launched in 2021 by the Prime Minister, the **Ayushman Bharat Digital Mission** will provide a **digital health ID** to the people who will hold their health records.
- The pilot project of Ayushman Bharat Digital Mission was announced on August 15, last year. Currently, the programme is being implemented in the pilot phase in six union territories (Chandigarh, Ladakh, Dadra and Nagar Haveli and Daman and Diu, Puducherry, Andaman and Nicobar Islands and Lakshadweep).

Features of the Mission

- It is a digital health ecosystem under which **every Indian citizen will now have unique health IDs, digitised health records with identifiers for doctors and health facilities.**
- The scheme will come under **the Ayushman Bharat Pradhan Mantri Jan Arogya Yojana.**
- It **comprises six key building blocks** – HealthID, DigiDoctor, Health Facility Registry, Personal Health Records, e-Pharmacy and Telemedicine.
- The **National Health Authority** has been given the mandate to design, build, roll-out and implement the mission in the country.
- **The core building block of the mission** is that the Health ID, DigiDoctor and Health Facility Registry shall be owned, operated and maintained by the Government of India.
- **Private stakeholders will have an equal opportunity** to integrate and create their own products for the market. The core activities and verifications, however, remain with the government.
- Under the Mission, **every Indian will get a Health ID card** that will store all medical details of the person including prescriptions, treatment, diagnostic reports and discharge summaries.
- **Health ID is a randomly generated 14-digit number** used for the purpose of uniquely identifying persons, authenticating them, and threading their health records (only with their informed consent) across multiple systems and stakeholders.
- The **citizens will be able to give their doctors and health providers one-time access to this data** during their visits to the hospital for consultation.

Need for this Mission

- The mission aims to liberate citizens from the challenges of finding the right doctors, seeking appointment, payment of consultation fee, making several rounds of hospitals for prescription sheets among several others and will empower people to make an informed decision to avail the best possible healthcare.

24.22.6 Poshan Abhiyan

POSHAN Abhiyan was launched by Prime Minister Shri Narendra Modi in Jhunjhunu, Rajasthan in March 2018. It targets to reduce level of under-nutrition and other related problems by ensuring convergence of various nutrition related schemes. It also targets stunting, under-nutrition, anaemia (among young children, women and adolescent girls) and low birth rate.

It will monitor and review implementation of all such schemes and utilise existing structural arrangements of line ministries wherever available. Its large component involves gradual scaling-up of interventions supported by on-going World Bank assisted Integrated Child Development Services (ICDS) Systems Strengthening and Nutrition Improvement Project (ISSNIP) to all districts in the country. Originally, the program was designed to span three years until March 2021, with a focus on addressing the prevalent issue of malnutrition in the nation. However, recognizing its effectiveness and potential, the government has consolidated multiple initiatives with similar goals, such as the Supplementary Nutrition Program and POSHAN Abhiyan, into a single comprehensive program known as Mission POSHAN 2.0. This integration aims to enhance operational efficiency, promote synergy, and adopt an integrated approach to delivering nutrition services.

These are key Nutrition strategies and interventions: IYCF (Infant and Young child feeding), Food and Nutrition, Immunisation, Institutional Delivery, WASH (Water, Sanitation and Hygiene), De-worming, ORS-Zinc, Food Fortification, Dietary Diversification, Adolescent Nutrition, Maternal Health and Nutrition, ECD (Early Childhood development)/ECCE (Early Childhood Care and Education), Convergence, ICT-RTM (Information and Communication. Technology enabled Real Time Monitoring) and Capacity Building etc.

Anaemia Mukt Bharat

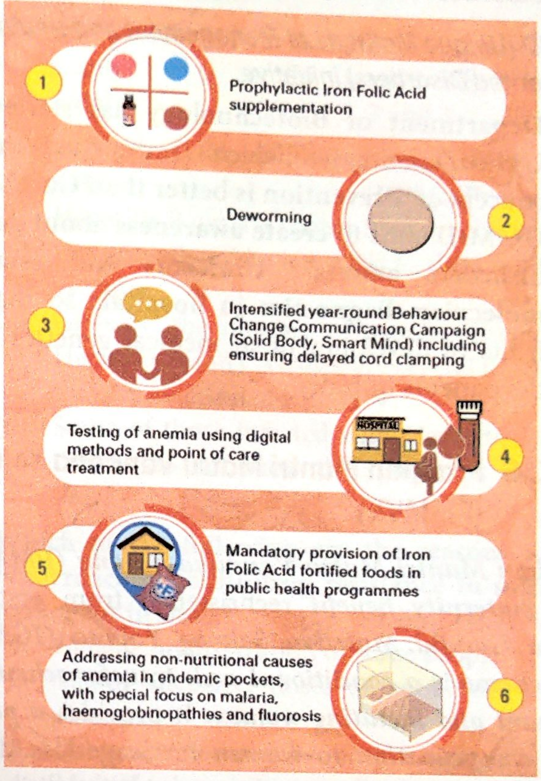
The *Anaemia Mukt Bharat* – intensified Iron-plus Initiative aims to strengthen the existing mechanisms and foster newer strategies for tackling anaemia.

It focuses on six target beneficiary groups, through six interventions and six institutional mechanisms to achieve the envisaged target under the *Poshan Abhiyan*.

The Anaemia Mukt Bharat strategy has been designed to reduce prevalence of anaemia by 3 percentage points per year among children, adolescents and women in the reproductive age group (15–49 years), between the year 2018 and 2022.

The Anaemia Mukt Bharat strategy will be implemented in all villages, blocks, and districts of all the States/UTs of India through existing delivery platforms as envisaged in the National Iron Plus Initiative (NIPI) and Weekly Iron Folic Acid Supplementation (WIFS) programme.

It will focus on the following interventions:


1
Prophylactic Iron Folic Acid supplementation
Deworming
2
3
Intensified year-round Behaviour Change Communication Campaign (Solid Body, Smart Mind) including ensuring delayed cord clamping
Testing of anemia using digital methods and point of care treatment
HOSPITAL
4
5
Mandatory provision of Iron Folic Acid fortified foods in public health programmes
Addressing non-nutritional causes of anemia in endemic pockets, with special focus on malaria, haemoglobinopathies and fluorosis
6

24.22.7 'UMMID' Initiative

Government launches **'UMMID' initiative** to **tackle inherited genetic diseases of new born babies.**

UMMID initiative aims to establish NIDAN **(National Inherited Diseases Administration)** Kendras to provide counselling, prenatal testing and diagnosis, management, and multidisciplinary care in Government Hospitals wherein the influx of patients is more.

- Produce skilled clinicians in Human Genetics.
- Undertake screening of pregnant women and new born babies for inherited genetic diseases in hospitals at aspirational districts.

Need for and Significance of the Initiative

- In India's urban areas, congenital malformations and genetic disorders are the third most common cause of mortality in newborns. With a very large population and high birth rate, and consanguineous marriage favoured in many communities, prevalence of genetic disorders is high in India.

- **Establishment of patient care services for genetic disorders** is the need of the time.

UMMID (Unique Methods of Management and treatment of Inherited Disorders) initiative

- **Department of Biotechnology** has started the UMMID Initiative which is designed on the concept of **'Prevention is better than Cure'.**
- UMMID aims to **create awareness about genetic disorders amongst clinicians and establish molecular diagnostics in hospitals** so that the fruits of development in medical genetics reach the patients in India.

24.22.8 Pradhan Mantri Matru Vandana Yojana (PMMVY)

Pradhan Mantri Matru Vandana Yojana (PMMVY) is ***a maternity benefit*** rechristened from erstwhile ***Indira Gandhi Matritva Sahyog Yojana (IGMSY).*** The scheme is ***a conditional cash transfer scheme for pregnant and lactating women.*** It provides ***a partial wage compensation to women*** for wage-loss during childbirth and childcare and to provide conditions for safe delivery and good nutrition and feeding practices.

Objectives

1. Promoting appropriate practice, care and institutional service utilisation during pregnancy, delivery and lactation.
2. Encouraging the women to follow (optimal) nutrition and feeding practices, including early and exclusive breastfeeding for the first six months.

States/UTs and districts are awarded for best performance under PMMVY.

Key Performers

1. In the category of ***best performance since inception of the Scheme*** to States/UTs ***having population of more than 1 crore*** the ***first position was awarded to the state of Madhya Pradesh,*** followed by Andhra Pradesh and Haryana in the third position.
2. In the same category ***among States/UTs having population of less than 1 crore,*** Dadra & Nagar Haveli is in the first position. Himachal stood second and Chandigarh is at the third position.
3. ***In the District level awards for States/UTs with population of more than 1 crore,*** the ***first position went to Indore in Madhya Pradesh.*** In the same category for States/UTs with population under than 1 crore, the first position went to Serchhip in Mizoram.
4. Providing cash incentives for improved health and nutrition to pregnant and lactating mothers.

QUESTIONS AND ANSWERS

25.1 CORONAVIRUS

It is ***a new virus identified by Chinese researchers.*** It was responsible for a new pneumonia-like illness that had swept Wuhan city of China since December 2019, leaving many ill and created panic.

25.1.1 Key Facts

- Coronaviruses (CoV) are a large family of viruses (Coronaviridae family) that cause illness ranging from the common cold to more severe diseases such as Middle East Respiratory Syndrome (MERS-CoV) and Severe Acute Respiratory Syndrome (SARS-CoV).
- Coronaviruses are ***zoonotic,*** meaning they are transmitted between animals and people.
- Coronaviruses can affect mammals including pigs, cattle, cats, dogs, martens, camels, hedgehogs and some birds.
- A coronavirus has many 'regularly arranged' protrusions on its surface, because of which the entire virus particle looks like an emperor's crown, hence the name 'coronavirus'.

So far, there are four known disease-causing coronaviruses, among which ***the best known are the SARS coronavirus and the Middle East Respiratory Syndrome (MERS) coronavirus, both of which can cause severe respiratory diseases.***

WHO Declared CoV a Public Health Emergency

World Health Organization (WHO) declared coronavirus ***a public health emergency of international concern.***

25.1.2 What Necessitated This

- Rising numbers and evidence of person-to-person transmission in a handful of cases outside of China.
- Greatest concern is the potential for the virus to spread to countries with weaker health systems, and which are ill-prepared to deal with it.

25.2 WHAT IS A PUBLIC HEALTH EMERGENCY OF INTERNATIONAL CONCERN

- As per the WHO, it is 'an extraordinary event' that constitutes a 'public health risk to other States through the international spread of disease' and 'to potentially require a coordinated international response'. Previous emergencies include Ebola, Zika and H1N1.
- ***The responsibility of declaring an event as an emergency lies with the*** Director-General of the WHO and requires the convening of a committee of members.

25.3 HOW WHO NAMES A NEW DISEASE

In February 2020, ***the World Health Organization*** officially announced ***COVID-19 (Corona Virus Disease – 2019)*** as the name for the disease caused by the novel coronavirus. The 'CO' in COVID stands corona, while 'VI' is for virus and 'D' for disease. The number 19 stands for the year 2019 when the outbreak was first identified.

25.4 SCHEDULE H1 DRUG

The Drugs and Cosmetics Rules, 1945, are the set of rules under **the Drugs and Cosmetics Act, 1940,** which has ***provisions for classification of drugs into different schedules and also guidelines for storage, sale and display.*** **Schedule H1** has been introduced through Gazette notification GSR 588 (E) dated 30-08-2013 **to check the indiscriminate use of antibiotics, anti-TB and some other drugs in the country.** The schedule contains certain **third and fourth generation antibiotics, certain habit-forming drugs and anti-TB drugs.**

As per the government notification, these drugs are required to be sold in the country with the following conditions:

1. The supply of a drug specified in Schedule H1 shall be recorded in a separate register at the time of the supply giving the name and address of the prescriber, the name of the patient, the name of the drug and the quantity supplied and such records shall be maintained for three years and be open for inspection.
2. The drug specified in Schedule H1 shall be **labelled** with the **symbol Rx** which shall be in **red** and conspicuously displayed on the left top corner of the label, and shall also be labelled with the **symbol Rx** in a box with a red border.

25.4.1 Implications of This Classification

- It restricts its sale only based on prescription.
- The sale of the drug from now on should be in accordance with the conditions for sale of drugs as specified in Schedule H1 to the Drugs and Cosmetics Rules, 1945.
- This would mean that any preparation containing the said drug would have a warning label of 'only prescription sale' and against self-medication.

The government has notified anti-malarial drug **hydroxychloroquine** under **Schedule-H1.** This was done in exercise of its powers conferred by **Section 26B of the Drugs and Cosmetics Act, 1940 (23 of 1940).** The move is aimed at stopping the misuse of the drug which has now been allowed by the government for prophylactic use in high-risk contacts of COVID-19 patients and healthcare workers treating such patients.

5.5 WHO DECLARES CORONAVIRUS A PANDEMIC

As fresh coronavirus cases continue to be reported from different countries, **the World Health Organization** finally declared the novel coronavirus a **'pandemic'.** WHO said it was deeply concerned both by **the alarming levels of spread and severity of the disease and inaction.** Earlier, on 30 January, 2020 the WHO declared it as **a 'Public Health Emergency of International Concern'.**

25.5.1 What is an Outbreak, Epidemic and Pandemic

1. An **outbreak** is understood to be a ***sudden rise in the cases of a disease*** at a particular place.
2. An **epidemic** is a ***large outbreak among a particular population or region.***
3. A **pandemic** is ***'the worldwide spread of a new disease'.* There is no specific number of countries that a disease must touch for WHO to classify it as a pandemic.**

Previous Pandemics

- In June 2009, the WHO declared novel influenza A (H1N1), commonly known as **swine flu, as a pandemic.**

25.5.2 Symptoms of COVID-19

- COVID-19 is **similar to other respiratory illnesses and its symptoms include *fever, dry cough, sore throat and headache. There may also be aches and pains, fatigue and, in some cases, vomiting and diarrhoea.***
- While most cases are mild, some individuals may experience more severe symptoms such as ***shortness of breath and difficulty breathing, and may experience pneumonia in both lungs.*** Those with health issues or underlying conditions may also have a harder time recovering.
- ***It may take up to fourteen days after exposure for symptoms to appear.***

25.5.3 How is COVID-19 Spread?

- COVID-19 is ***transmitted through liquid droplets or particles when a person coughs, sneezes or breathes.*** These droplets, if containing the virus, can infect a person by ***entering through the eyes, nose or throat.*** It is not believed to be airborne and not known to infect via the skin.
- However, the virus can survive on some surfaces so if a person sneezes onto their hands, then shakes hands with a person and the latter then rubs his/her eyes/nose/mouth, then, transmission is possible through self-inoculation.

25.5.4 What is the Difference between Common Cold, Flu and COVID-19

- All three are **respiratory illnesses but each is caused by different viruses.**
- The common cold is caused by the **rhinovirus,** the flu is caused by the **influenza virus,** and COVID-19 is caused by the novel 2019 **coronavirus.**
- All three can lead to pneumonia if complicated by other health issues or underlying conditions.

25.5.5 What is the 'Rapid Test'?

To tackle suspicions of whether the novel coronavirus has spread into the community and if not, then to prevent such a scenario, the **Kerala Government** announced **'rapid tests'** to **ensure speedy results within half-an-hour.**

25.5.5.1 What is the 'Rapid Test' for Coronavirus?

- A rapid test is **conducted to determine whether there has been any kind of recent viral infection in a person's body.**
- When a pathogen enters a human body, specific antibodies are released as a response to the virus.
- ***A rapid test can detect the presence of such antibodies in blood, serum or plasma samples quickly, indicating a viral infection.*** Rapid testing is conducted usually **to check for community transmission of a virus during an epidemic.**
- According to the health department, it is a simple test that can be done with a person's blood sample and ***will give results within 10–30 minutes.*** It is also a low-cost test.

25.5.5.2 What does Kerala's Health Department Planned to do?

- Rapid tests can be used to conduct screening within the community and identify those with suspected infection, put them under observation and if required, subject them to the Reverse Transcriptase-Polymerase Chain Reaction (RT-PCR) for coronavirus confirmation.
- Kerala's Health Department planned to acquire as many rapid antibody kits as possible from ICMR-NiV and begin to use them, especially on those under quarantine in areas like Kasaragod district which reported 80 of the 181 active cases. The situation in Kasaragod was critical than in other districts and had been met with stricter lockdown measures by the administration.

25.6 ACE 2 RECEPTORS

The SARS-CoV-2 virus enters a human cell through 'ACE2 receptors', which are enzymes **that generate small proteins that are useful for the cell.**

In the search for treatment for COVID-19, many researchers are focusing their attention on a specific protein that allows the virus to infect human cells. Called the angiotensin-converting enzyme 2, or ACE2 receptor, the protein provides the entry point for the coronavirus to hook into and infect a wide range of human cells.

ACE2 is a protein on the surface of many cell types. It is an enzyme that generates small proteins – by cutting up the larger protein angiotensinogen – which then go on to regulate functions in the cell.

Using the spike-like protein on its surface, the SARS-CoV-2 virus binds to ACE2–like a key being inserted into a lock–prior to entry and infection of cells. Hence, ACE2 acts as a cellular doorway – a receptor – for the virus that causes COVID-19.

25.7 CONVALESCENT PLASMA THERAPY

Plasma is the liquid part of the blood. **Convalescent plasma,** extracted from the blood of patients recovering from an infection, is a source of antibodies against the infection. The therapy involves using their plasma to help others recover. **For COVID-19,** this has been one of the treatment options. The donor would have to be a documented case of COVID-19 and healthy for twenty-eight days since the last symptoms.

25.7.1 How it Functions?

- The plasma bank functions like a blood bank, and has been created specifically for those who are suffering from COVID-19, and have been advised the therapy by doctors.
- The bank coordinates with patients who have recovered from COVID-19, and are eligible to donate plasma.

25.7.2 Who can Donate Plasma?

- Those who had the disease, but have recovered at least fourteen days before the donation can be considered.
- **People between the ages 18 and 60, and weighing not less than 50 kg are eligible.**
- Women who have given birth recently are not eligible, as the antibodies they produce during pregnancy (after being exposed to the blood of the foetus) can interfere with lung function.

How is Plasma Donation Different from Blood Donation?

- In plasma donation, as opposed to blood donation, **only plasma is extracted and the other components of blood are returned to the body.**
- **Blood contains several components,** including red blood cells, platelets, white blood cells and plasma.

- **Five hundred millilitres of plasma can be donated every two weeks,** while blood can be donated once in three months.

25.7.3 How Plasma Therapy Works?

1. Blood is drawn from a person who has recovered from COVID-19 sickness.
2. The serum is separated and screened for virus-neutralising antibodies.
3. **Convalescent serum,** that is the blood serum obtained from one who has recovered from an infectious disease and especially rich in antibodies for that pathogen, is then administered to a COVID-19 patient.
4. The sick acquires passive immunisation.

25.7.4 How Long the Antibodies will Remain in the Recipient?

After the antibody serum is given, it will stay in the recipient for **at least three to four days.** Various studies have confirmed that during this period, the sick person usually recovers.

25.7.5 Plasma Therapy Debate

- The Indian Council of Medical Research (ICMR) has dropped the plasma therapy from the national guidelines as it found that convalescent plasma was ineffective in arresting COVID-19.
- In China and Netherlands too, the plasma therapy yielded very little or no results.

COVID care is individualised care. Use of the right drugs in the right patient does work. Experts say that use of convalescent therapy has saved some lives but concerns have been raised by the PLACID trial. Therefore, the potential harms of the non-immune components of convalescent plasma should be rigorously investigated; only donor plasma with detectable titers of neutralising antibodies should be given to trial participants, to ensure that the potential for benefit exists.

INDIA'S FIRST PLASMA BANK

- Established at the Institute of Liver and Biliary Sciences (ILBS), Delhi.
- Aim: To ease access to plasma that is being used as a trial to treat COVID-19 patients.

25.7.6 WHO Guidelines in This Regard

WHO guidelines in 2014 mandate a donor's permission before extracting his/her plasma. Plasma from only recovered patients must be taken, and donation must be done from people not infected with HIV, hepatitis, syphilis or any infectious disease. ***If whole blood is collected, the plasma is separated by sedimentation or centrifugation, then injected in the patient.*** If plasma needs to be collected again from the same person, it must be done ***after twelve weeks of the first donation for males and sixteen weeks for females,*** the WHO guidelines state.

25.7.7 B-Cells and T-Cells

B-cells

- B stands for '**bone marrow**', in which these cells mature.
- B-cell function is threefold:
  1. Antigen presentation to other immune cells
  2. Cytokine secretion
  3. Antibody production
- The most important function of B-cells is **humoral (antibody-driven) immunity** that is antibody production to fight bacteria and viruses.
- These antibodies are Y-shaped proteins that are specific to each pathogen and are able to lock onto the surface of an invading cell and mark it for destruction by other immune cells.
- When naive B-cells comes in contact with antigen that fits its receptor, it binds to it and takes it inside its membrane for processing which leads to formation of antigen-MHC complexes that T-cells bind to and release cytokines. These T-cell cytokines activate the B-cell.
- Inactivated B-lymphocytes also act as antigen-presenting cells (APCs) which attach to an antigen (foreign particle) and process it, producing membrane markers that act as a warning that a T-cell can understand.
- B-lymphocytes present these antigen-MHC complexes to T-cell receptors, causing T-cell activation.
- Where the non-specific immune system (the innate immune system) is concerned, this reaction produces the opposite effect–T-cell inactivation

that is B-lymphocytes also help prevent auto-immune reactions.

- B-lymphocytes release cytokines (essential for cell-to-cell communication) which invites white blood cells in the form of phagocytes to the areas where B-cell antibodies have attached to antigens.

T-cells

- A type of white blood cell (lymphocyte) that is of key importance to the immune system.
- T-cells tailor the body's immune response to specific pathogens.
- They are like the soldiers who search out and destroy the targeted invaders.
- The 'T' stands for '**thymus**' – the organ in which these cells mature.
- **Types of T-cells:** There are two main types of T-cells:
  1. **Helper T-cells** stimulate B-cells to make antibodies and helps develop killer cells.
  2. **Killer T-cells** directly kill cells that have already been infected by a foreign invader.

What do T-cells use?

T-cells use cytokines as messenger molecules to send chemical instructions to the rest of the immune system.

Note: The **primary and secondary immune responses** are carried out with the help of two special types (T-cells) of lymphocytes present in our blood, i.e., B-lymphocytes (B-cells) and T-lymphocytes. The B-lymphocytes produce an army of proteins in response to pathogens into our blood to fight with them. These proteins are called antibodies. The T-cells themselves do not secrete antibodies but help B-cells produce them.

25.8 CORONAVIRUS STRAIN ISOLATED IN INDIA

India is only the fifth country in the world besides Japan, Thailand, the United States and China **to have successfully isolated the COVID-19 virus strain,** helping it take the first step towards expediting the development of drugs, vaccines and rapid diagnostic kits in the country.

25.9 OPERATION NAMASTE

Indian Army launched 'Operation Namaste' to contain the spread of coronavirus in the country. Under the operation, the ***army helped the Government of India fight against the deadly disease. Under the operation, Indian Army had established eight quarantine centres. Also, Command-wise help line numbers were established.***

25.10 RT-PCR TEST

The causative agent for COVID-19 is the **SARS-CoV-2 virus.** It is **an RNA virus that** means it infiltrates a healthy cell to multiply and survive. Thus, **the RT-PCR test is for the identification of SARS-CoV-2 RNA.** In this, **the RNA is converted to DNA through a process called 'reverse transcription' for detecting the virus.**

The SARS-CoV-2 RNA is **generally detectable in respiratory specimens** during the acute phase of infection.

1. For that **upper and lower respiratory specimens (such as nasal, nasopharyngeal) are collected.**
2. This **sample is treated** with several chemical solutions that remove substances, such as proteins and fats, and **extracts only the RNA present in the sample.**
3. Real-time RT-PCR setup usually **goes through 35 cycles,** which means that by the end of the process, **around 35 billion new copies of the sections of viral DNA are created** from each strand of the virus present in the sample.
4. As new copies of the viral DNA sections are built, **the marker labels attach to the DNA strands** and then release **a fluorescent dye,** which is measured by the machine's computer and presented in real-time on the screen. The computer tracks the amount of fluorescence in the sample after each cycle. **When the amount goes over a certain level of fluorescence, this confirms that the virus is present.**

The boon and bane of RT-PCR testing are in its **capacity to amplify even one viral gene segment in the sample to generate a detectable signal** – a positive test.

1. It is a boon because it **accurately detects the presence of virus.**
2. It is a bane because it is **prone to false-negative and false-positive results.**

False RT-PCR Reports

- During sample preparation for testing, if even one gene segment falls into the tube from the laboratory environment, it will be amplified and the test will be positive – but, **false positive. A false negative PCR** means that a person with infection was missed by the test, but that is in the very nature of PCR. **The viral load is lower in the throat than in the nasopharynx.**

- Hence, throat swabs are falsely negative in 60% of tests and nasopharyngeal swabs in 30%, according to published studies.
- **An incorrectly taken nasal swab may miss the virus altogether and lead to a false-negative test.**

25.11 'FELUDA' TEST FOR COVID-19 APPROVED BY INDIA

- FELUDA is the acronym for FNCAS9 Editor Linked Uniform Detection Assay.
- It is an accurate and low-cost, paper-based test strip to detect COVID-19. It takes less than thirty minutes to show the results.
- It was approved by the Drugs Controller General of India for launching it commercially.
- It was developed by the Council of Scientific and Industrial Research (CSIR) and Tata Group.
- It uses indigenously developed CRISPR gene-editing technology to identify and target the genetic material of SARS-CoV2, the virus that causes COVID-19.

Significance

- According to CSIR, the test matches accuracy levels of RT-PCR tests.
- It has a quicker turnaround time and requires less expensive equipment.
- 'FELUDA' is also the world's first diagnostic test to deploy a specially adapted Cas9 protein to successfully detect the virus.

What is CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) Technology?

- It is a gene editing technology and is used in correcting genetic defects and treating and preventing the spread of diseases.
- The technology can detect specific sequences of DNA within a gene and uses an enzyme functioning as molecular scissors to snip it.
- It also allows researchers to easily alter DNA sequences and modify gene function.
- The technology can also be configured for detection of multiple other pathogens in the future.

25.12 VITAMIN-D AND ITS SIGNIFICANCE

There have been considerable discussions in scientific circles on **the importance of vitamin D in these days of the COVID-19 pandemic.**

- It is **produced when sunlight (or artificial light, particularly in the ultraviolet region of 190–400 nm wavelength)** falls on the skin and triggers **a chemical reaction to a cholesterol-based molecule, and converts it into calcidiol in the liver and into calcitriol** in the **kidney.**
- Vitamin D is a fat-soluble vitamin, meaning that it dissolves in fats and oils and can be stored in your body for a long time.

Its Role

- It is known to help in having **the right amount of calcium in the bones,** catalyse **the process of protecting cell membranes from damage,** preventing the inflammation of tissues and helping stop tissues from forming fibres and weakening bones from becoming brittle, leading to **osteoporosis.**
- **Vitamin D deficiency can affect COVID-19 high-risk patients, particularly those who are diabetic, have heart conditions, pneumonia, obesity and those who smoke.**
- It is also associated with infections in the respiratory tract and lung injury.

Need for Supplementation

- According to a study, **India, a nation of abundant sunshine, is surprisingly found to have a massive burden of vitamin D deficiency** among the public irrespective of their location (urban or rural), age or gender, or whether they are poor or even rich. Hence, it is clear that vitamin D supplementation is necessary for most Indians to treat its deficiency.

25.13 ELECTRONIC VACCINE INTELLIGENCE NETWORK (EVIN)

The eVIN network is being repurposed for the delivery of the COVID-19 vaccine.

- The eVIN is an innovative technological solution aimed at strengthening immunisation supply chain systems across the country. This is being implemented under the National Health Mission

(NHM) by the Ministry of Health and Family Welfare.

- It aims to provide real-time information on vaccine stocks and flows, and storage temperatures across all cold chain points in the country.

Benefits of eVIN

- It has helped create a big data architecture that generates actionable analytics encouraging data-driven, decision-making and consumption-based planning.
- It helps in maintaining optimum stocks of vaccines leading to cost savings. Vaccine availability at all times has increased to 99% in most health centres in India.
- While instances of stock-outs have reduced by 80%, the time taken to replenish stocks has also decreased by more than half, on an average.

25.14 IMPORTANT VACCINES AGAINST COVID

1. Covaxin

- The first and the only indigenously developed vaccination against Covid-19 by **Bharat Biotech** in association with the **Indian Council of Medical Research (ICMR)** and the **National Institute of Virology (NIV)**.
- Covaxin is an **inactivated viral vaccine.** This vaccine is developed with Whole-Virion Inactivated Vero Cell-derived technology. They contain inactivated viruses, which cannot infect a person but still can teach the immune system to prepare a defence mechanism against the active virus .
- The **effectiveness of Covaxin is 81%** according to interim 3rd phase trial results.
- The interval between the 2 doses is 4–6 weeks.
- This vaccine can be 78–95% effective after the second dose.

2. Covishield

- Covishield has been developed by the **Oxford University** in collaboration with **AstraZeneca** and is being manufactured by the **Serum Institute of India (SII).**
- It has been prepared using the **viral vector platform.**
- A replication-deficient chimpanzee adenovirus (cold virus), ChAdOx1 which has been modified to enable it to carry the Covid-19 spike protein into the cells of humans.
- It is basically incapable of infecting the receiver but teaches the immune system to recognise the Covid-19 spike protein as a threat and work on building antibodies against it.
- The **effectiveness of the Covishield vaccine is nearly 90%** as per the global reports
- The interval between 1st and 2nd doses is 12–16 weeks.
- Efficacy after the second dose can vary from 70–90%.

3. Pfizer (Comirnaty/BioNTech)

- It is jointly developed by **Pfizer** and **BioNTech.**
- It uses **mRNA (messenger RNA) technology.**
- It **relies on synthetic genes** that can be generated and manufactured in weeks, and produced at a scale more rapidly than conventional vaccines.
- The vaccine works by introducing mRNA into the cells. This mRNA teaches cells to make a protein from the Covid-19 virus. The body detects this protein and triggers a robust immune response. This creates antibodies, as well as long-lasting immunity against SARS-CoV-2 infections.
- After the body produces an immune response, it discards all of the vaccine ingredients, just as it would discard any substance that cells no longer need.

4. Sputnik (Gamaleya)

- It is an **adenovirus-based vaccine** created by the **Gamaleya National Centre of Epidemiology and Microbiology.**
- Sputnik V is a **combined vector vaccine,** which means it uses inactivated viruses called vectors.
- Unlike other types of vaccines, Sputnik V does not contain any form of the SARS-CoV-2 virus. Instead, it relies on a **modified version of two different adenoviruses – known as rAd26 and rAd5.**
- It has been modified to contain the SARS-CoV-2 spike protein to create immunity against Covid-19.
- When the vaccine enters the body, the adenovirus vectors within the vaccine enter the cells and recreate the spike protein found on the SARS-

CoV-2 virus. As soon as the cell recognises this foreign spike protein, the immune system kicks in and begins to make antibodies against the virus.

25.15 WHY DO VIRUSES MUTATE?

- A mutation just means a difference; a letter change in the genome.
- Mutations in viruses are a natural part of evolution.
- The pressure on the virus to evolve is increased by the fact that so many millions of people have now been infected.

What is the COVID-19 Mutant Strain?

- It has been named VUI-202012/01 (the first 'Variant Under Investigation' in December 2020) and is defined by a set of 17 changes or mutations. As on 13 December 2020, a total of 1,108 cases with this new variant had been identified, predominantly in the South and East of England where cases have been rising.

How Harmful is the New COVID Strain?

- This new variant is showing some 17 changes in the genome, this is a very large change. Due to this change, the transmissibility of this virus has also changed and is seventy per cent more infectious compared to the earlier variant.
- There is a high possibility that the new strain is still in the UK as it has not been detected in other parts of Europe.

UK Vaccine is a Global Game Changer

- The approval of the Oxford-AstraZeneca vaccine in the UK made a significant impact on the spread of the COVID-19 coronavirus as it is the most accessible shot approved so far and is likely to remain that way.
- This is significant for India, as the Pune-based Serum Institute of India (SII) has tied up with AstraZeneca to deploy the vaccine in the country.

How this Vaccine Works?

- This new vaccine is a viral vector vaccine, which works in a different way than the mRNA vaccines that have already been approved.
- A viral vector vaccine uses another non-replicating virus to deliver SARS-CoV-2 genes, in the form of DNA, into human cells, where viral proteins are produced to induce protective immune responses.

Concern

- The presence of the chemicals in the blood samples was very less as the patients were recovering fast. If the quantity of the toxins was high, or spread through air, it would affect the neurological system.

25.16 MONOCLONAL ANTIBODIES WORK AGAINST COVID

Immunity of human body works as a defence mechanism against pathogens (i.e., disease-causing agents, like virus, bacteria, etc.), those prompting the production of antibodies.

The bodies of the majority of people who recover from COVID-19 produce antibodies to the SARS-CoV-2 virus. Scientists have found that these antibodies persist for at least 5–7 months after the infection.

Scientists can also produce these antibodies in a laboratory setting to be infused into the blood, i.e., **monoclonal antibodies (mAb).** mAb are identical copies of an antibody that targets one specific antigen. Scientists can make monoclonal antibodies by exposing the white blood cells to a particular antigen. They can then select a single white blood cell or clone and use this as the basis to produce many identical cells, making many identical copies of the monoclonal antibody. Monoclonal antibodies have been used earlier against Ebola and HIV disease. Each monoclonal antibody is specific to its matching antigen. In this way, against COVID-19, there are several authorised monoclonal antibody therapies applied.

The SARS-CoV-2 virus's spike glycoprotein, which sits on its surface, functions to facilitate the virus's entry into the body's cells. Some SARS-CoV-2 antibodies bind to the spike protein and prevent the virus from entering the cell. Currently, all the monoclonal antibodies for COVID-19 for which the **FDA (Food and Drug Administration, USA)** have issued emergency use authorisation target the spike protein.

25.17 mRNA VACCINE TECHNOLOGY

Messenger RNA or mRNA technology works by teaching our cells to recognise and protect us against infectious diseases. One of the challenges with this new technology is that it must be kept cold to maintain stability during transport and storage.

mRNA Vaccines

- mRNA vaccines **trick the body into producing some of the viral proteins itself.**
- They work by using **mRNA** which is **the molecule that essentially puts DNA instructions into action.**
- Inside a cell, mRNA is used as a template to build a protein.

How it works?

1. To produce an mRNA vaccine, scientists produce a synthetic version of the mRNA that a virus uses to build its infectious proteins.
2. This mRNA is delivered into the human body, whose cells read it as instructions to build that viral protein, and therefore create some of the virus's molecules themselves.
3. These proteins are solitary, so they do not assemble to form a virus.
4. The immune system then detects these viral proteins and starts to produce a defensive response to them.

Significance of mRNA vaccines

- There are two parts to our immune system: **innate** (the defences we're born with) and **acquired** (which we develop as we come into contact with pathogens).
- **Classical vaccine molecules** usually only work with the acquired immune system and the innate immune system is activated by another ingredient called an **adjuvant.**
- Interestingly, **mRNA in vaccines could also trigger the innate immune system,** providing an extra layer of defence without the need to add adjuvants.

Self-replicating mRNA Covid-19 vaccines

A California based pharmaceutical company has developed **ARCT-154, a self-amplifying mRNA vaccine** against Covid-19 infection.

Benefits: It offered 95% protection against severe Covid-19 and 55% against Covid infection.

QUESTIONS AND ANSWERS

26.1 HEAVY WATER

In 1932, Dr. H. C. Urey discovered heavy water and got the Nobel Prize. In heavy water, one of hydrogen's isotopes, deuterium is used. Heavy water is also popularly called as deuterium oxide (D_2O).

26.1.1 Various Uses of Heavy Water

- Deuteration of drugs, altered metabolism of some drugs, which could lead to increased duration of pharmacological action and/or reduction of toxic manifestation.
- By deuterated drugs, therapeutic **efficiency is enhanced.**
- In the **preservation of several tissues/organs;** e.g., kidneys can be preserved without degradation or decay.
- **Deuteration of anticancer drugs decreases side effects,** while also retaining its efficacy.
- Heavy water can also be used in **nuclear magnetic resonance spectroscopy**. It can control blood pressure in humans.
- D_2O is used as a **moderator** in certain nuclear reactors and it can also be used as cooling agent.
- **It increases the thermal stability of some vaccines** like oral polio vaccines or other macro-molecules, which had freezing temperature.

26.1.2 Harmful Effects of Heavy Water

- Its higher concentration in human body (approximately 50%) can cause cell dysfunctioning and death.
- It alters plant cell division process and hence plant growth is retarded.
- Its higher concentration (approximately 90%) severely affects aquatic life, i.e., kills fish, tadpoles, flatworms, drosophila etc.

Differences between Normal water (H_2O) and Heavy water (D_2O):

- D_2O is more viscous than H_2O due to high melting point and boiling point.
- D_2O exhibits around 2600 times neutron-moderating ability as compared to H_2O.

26.1.3 Indian Data regarding Heavy Water

India is the world's largest producer of heavy water. India has made its production self-reliant. India exports high-quality D_2O to several countries like the United States and the Republic of Korea.

Heavy Water Board is a constituent unit, which is under the Department of Atomic Energy in the Government of India. The organisation is tasked with and is responsible for production of D_2O that can be used both as a 'moderator' and a 'coolant' in nuclear reactors. But D_2O is used as a good moderator and not as a coolant.

The research in D_2O production was started by Bhabha Atomic Research Centre (BARC) in 1960s. The first heavy water reactor plant in India was established at Nangal, Punjab. Heavy Water Board is operating in seven heavy water plants around the country – Baroda in Gujarat, Tuticorin in Tamil Nadu, Kota in Rajasthan, Thal in Maharashtra, Hazira in Gujarat, Talcher in Odisha and Manuguru in Telangana.

Note: Argentina, the Soviet Union, the United States, Norway, Canada, Pakistan, France etc., are other countries of heavy water producer in the world.

26.2 3D PRINTER, 4D PRINTING AND ORGAN PRINTING

26.2.1 3D Printing

3D printing/additive manufacturing/rapid prototyping is a process of making three-dimensional solid objects with the help of a digital file/format.

A 3D-object is printed by using additive processes or successive layering method. These layers are in the form of thinly sliced horizontal cross section of the eventual object.

Invention of 3D Printing

The first patent of 3D printing was given in 1986, when stereolithography apparatus (SLA) was used for object printing. This machine was first invented by Charles (Chuck) Hull in 1983. 3D printing becomes possible through three steps – Modelling, Printing and Finishing.

1. **Modelling:** Before going to print any object, a computer should have **computer-aided design (CAD)** or **animation modelling software**, which can store a digital format in computer.

2. **Printing:** After modelling, the next step is printing, where the liquid nature of cartridges used to dry in successive layers and form a complete object in a particular shape or geometric feature.
3. **Finishing:** In the case of any mismatch in object's shape or size, this object will again go in printing and then proper finishing becomes possible.

Materials Used in 3D Printing

Many different materials can be used for 3D printing, such as glass-filled polyamide, stereolithography materials (epoxy resins), silver, titanium, steel, wax, photopolymers, ABS plastic, PLA, polyamide (nylon), polycarbonate etc.

Uses of 3D Printing in Various Industries

Aerospace Industry, Architecture Industry, Automotive Industry, Commercial Products, Consumer Goods Industry, Consumer Electronics, Defence Industry, Dental Industry, Education Industry, Medical Industry, Moulding Industry etc.

Note: **'Foodini'** (3D Printer for Food) is a 3D printer that uses edible ingredients.

Challenges Faced by 3D Printing

Anything can be made by 3D printer, so criminals can misuse it to create illegal products. 3D printers can also create issues of Intellectual Property Rights for the 3D printer users.

26.2.2 4D Printing

- In **4D printing,** a **3D-printed** object will transform itself into another modification under the influence of some additional effects as temperature, light or other environmental stimuli.
- **3D-printed** objects maintain fixed shape like any plastic or metal parts but **4D-printed** objects can transform themselves over time.
- Different types of material can be used as an expandable element of smart materials like **hydrogel and elements with shape memory as polymeric** materials. **Hydrogel** is capable of absorbing a large amount of water and can be programmed to shrink or expand with changes in external environmental conditions.
- **Elements with Shape Memory:** It can be considered as smart materials because of their ability to return in its original shape from a deformed shape when stimuli is applied. The shape-memory materials are cheaper and have low density. Some of the elements under research are carbon fibres, smart textile materials, programmable wood etc.

Possible Applications of 4D Printing

- **Medical devices** – for stents placed into blood vessels. Drug capsules that release medicine.
- **Home appliances** – control and adjust according to heat and humidity.
- **Clothes and Footwear**
  - ***Implants*** – for humans and animals made from biocompatible materials.
  - ***Soft robots*** – can activate without reliance on an electric device.
- **Smart valves**
  - ***Sensors*** for infrastructure lines.

26.2.3 Organ Printing/Bioprinting

It is a mode of integrating biology to use 3D printing technology. It is a technique (3D printer) that is used for the development of artificial organs.

Many types of organs are developed in different shapes, **flat** – such as skin, **vascular** – such as blood vessels or **hollow** – such as the bladder.

Here, artificial organs are prepared for transplantation with the help of the recipient's own cells, so they have no chance of organ rejection.

Process of Organ Printing

In bioprinting, **bioink** is used as a cartridge, which is a mixture of specific cells like stem cells etc. These stem cell layering forms on biopaper, which is made up of collagen, water and hydrogel. All these layers will fuse in successive manner when biopaper will be removed or dry. The new bioink contains two different polymer components used in medical industry: **a natural polymer extracted from seaweed** and **a sacrificial synthetic polymer.**

Benefits of Bioprinting

- No rejection of organs and DNA because own cells are used
- No need of immune-suppressant drugs that are required in normal organ transplant
- It will eliminate organ donation
- No need to wait for organ availability

26.3 NARCOANALYSIS, POLYGRAPHY TEST AND BRAIN MAPPING

This technique is used primarily in psychotherapy and in law enforcement for interrogation purposes. The term '**truth drug**' or '**truth serum**' refers to the barbiturate that is administered in narcoanalysis.

Concept

In the narcoanalysis test, the subject's inhibitions and mental defences are lowered by interfering with his/her nervous system with the use of drugs.

The narcoanalysis test is conducted by dissolving 3 grams of Sodium Pentothal or Sodium Amytal in 3000 millilitres of distilled water.

The drug suppresses the central nervous system, decreases blood pressure and then slows down the heart rate, thereby sending the subject into a hypnotic trance, resulting in a lack of inhibition.

In this condition, it becomes more difficult although not impossible for him/her to lie. In other words, whatever they speak is regarded as truth.

The subject is then interrogated by the investigating agencies. The subject is made to answer specific but simple queries. The answers given are recorded both in video and audio cassettes. This is either used as evidence in court or as an aid in the investigation.

Narcoanalysis is a type of **controlled administration** with the help of intravenous hypnotic medicine used in suspected person. **Hypnotic medicines are also called as truth drugs.**

Polygraph is also popular with the name of lie detector. It uses several instruments to check various activities in human body, such as blood pressure, pulse, respiration, breathing system and various other activities during any queries.

Brain mapping is a neuroscience technique where brain wave frequency is analysed. Here, **a sensor is attached to head and connected with on-board computer screen. These sensors monitor brain-based electrical activity and the result appears in the form of certain waves due to stimulus.**

Criticisms

The issue of adopting narcoanalysis test during interrogation in India has been widely debated. It raises serious ethical, legal and scientific questions. Some of the main points of criticism are:

1. **Violates fundamental rights: Right to silence and privacy violation.**
2. **Violates human rights and is a form of torture:** Narcoanalysis is a kind of **mental torture**, which works by inhibiting the nervous system and thus lowers the subject's inhibitions. It also violates the dignity of the individual. The unethical use of truth drugs is also classified as a form of torture as per the international law.
3. **Unreliable and inadmissible in court:** Narcoanalysis tests are not considered to be very reliable. Subjects under the influence may mix fact with fantasy, and thus give false or misleading answers.
4. **Suspects who are used to drug abuse** may not experience the intended effect of the barbiturate and may still remain 'in control'.
5. A narcoanalysis test report may have validity but as it includes confessions made by a semiconscious person, it must not be totally held admissible in court.

In Favour

1. However, it is pointed out that narcoanalysis can be a valuable aid in investigations. The police do not base their entire investigation on narcoanalysis alone. Narcoanalysis is only one among a variety of means employed.
2. The police must be permitted to use all available methods, so long as they do not violate any legal or ethical principles, since law enforcement is also important. Denying these methods can hamper the police in their investigations especially in cases such as terrorism where the defendant may use a variety of means to escape prosecution. Therefore, one has to take a balanced view.
3. Polygraph and brain mapping are not intrusive techniques like narcoanalysis and must be permitted to be used by police in their investigations.

In narcoanalysis test, the person is injected with 'truth serums', which causes the person to become uninhibited and talkative. Since it is still possible that people may lie under the influence of truth serums, it is not altogether reliable.

P300 Test

When the brain recognises a sound of a person, it generates a special type of electric wave, which is called a P300. Sensors are connected to the head of a person who is undergoing a P300 test and the subject is made to sit before a computer monitor. He/she is then shown certain images or made to hear certain sounds. The sensor monitors electrical activity in the brain and registers P300 waves, which are generated only if the subject has some connection with the stimulus, and in this case, it is pictures or sounds. The subject is not asked any question in P300 test. These tests are used by investigators to crosscheck their findings, and to determine if a suspect is telling the truth or make him/her reveal some facts pertaining to a case.

Status of Narco Test in India

India's Central Bureau of Investigation (CBI) has used intravenous barbiturates for interrogation on cases, including the 26/11 Mumbai attack suspect, Kasab. On 5 May 2010, the Supreme Court ruled that narco, polygraph and brain mapping tests are to be allowed only after prior consent of the accused. In another case, the Madhya Pradesh High Court allowed narco test in the investigation of killing of a tiger.

26.4 KEVLAR: BULLET PROOF JACKETS

Kevlar is simply a super-strong plastic. There are literally hundreds of synthetic plastics made by **polymerisation (polymeric material)**, with all of them having different properties. Kevlar's amazing properties are partly due to its internal structure, how its molecules are naturally arranged in regular, parallel lines and partly due to the way it is made into fibres that are knitted tightly together.

POLYMERIC MATERIAL

It is a **large molecule or macromolecule** composed of millions of repeated linked units, each a relatively **light and simple molecule.**

Polymeric materials deal with the subject areas of **Material Science and Organic Chemistry.**

- The polymer is a substance made up of a **large number of molecules** that link together to form larger molecules.
- **Example of polymeric material** – an example of a synthetic polymer is plastic. An example of a natural polymer is rubber.
- Nylon 6.6 is a **synthetic polymer called a polyamide** because of the **characteristic monomers of amides in the backbone chain.** Two different molecules (**adipic acid and hexamethylenediamine**) are combined to create repeat units of 6 carbon atoms, thus the name nylon 6.6.

Super-strong Kevlar is known for its use in body armour (bullet-resistant vests). The following are some of Kevlar's properties:

- It is strong as well as light in weight.
- It does not melt like plastics.
- It can be used even at very low temperatures.
- High tensile strength, high toughness and chemical stability at high temperatures in aromatic polyamides.
- Kevlar is capable of preventing attacks from different chemicals. Though, long exposure to strong acids or bases will degrade it over a period of time.

Note: Kevlar is widely used as a friction material in the automotive industry and a combustion protection material in the aerospace industry.

26.5 AGENT ORANGE

Agent Orange is the code name of a herbicide (plant-killing chemicals) developed for the US military, especially for use in tropical climates. 'Agent Orange' was named for the orange band that was used for marking of the drums it was stored in.

The product was synthesised to deny an enemy cover and concealment in dense terrain by defoliating trees and shrubbery where the enemy can hide.

Agent Orange was tested in chemical warfare, under the name of **Operation Ranch Hand,** which the US military unleashed on **Vietnam during 1961–1971. Agent Orange was an equal proportion (50:50) of** two chemicals, viz., 2,4-dichlorophenoxyacetic acid (2, 4, D) and 2, 4, 5-trichlorophenoxyacetic acid (2, 4, 5, T).

The mixed product was further mixed with kerosene or diesel fuel and dispersed by aircraft, vehicle and hand spraying. An estimated 19 million gallons of Agent Orange were used in South Vietnam during the war. It had devastating effects on the health of the people, which is being even passed onto the children.

Note: The most widely used herbicide was Agent Orange, followed by Agent White. Other tactical herbicides that were used in Vietnam during the war include Agent Blue, Agent Purple, Agent Pink and Agent Green.

Agent Purple

Agent Purple is reputed to have three times the dioxin levels of Agent Orange, 45 parts per million as opposed to 13 parts per million in Agent Orange.

Agent Blue

Defined in medical literature as 'an arsenic-based herbicide' used to destroy broadleaf plants and trees (including grass, rice, bamboo, banana trees etc.), used especially on rice paddies during the Vietnam War.

In News

The Second International Conference of Victims of Agent Orange/Dioxin was held from 7 to 10 August 2012 in Hanoi to commemorate the 15th anniversary of the use of the deadly Agent Orange in Vietnam.

26.6 HYDROPONICS, AEROPONICS AND AQUAPONICS

Refer **Infographic – Hydroponics vs. Aeroponics vs. Aquaponics**.

26.7 BIODIGESTER TECHNOLOGY OR BIOTOILET

The **Pitroda Committee** (for railway modernisation) and the **Kakodkar Committee** (for railway safety) had strongly recommended replacing the conventional open-discharge toilets with green toilets, with the aim of having cleaner, hygienic and safer railway ecosystem.

In recent years, bio-digester-based technology has been introduced with the help of **DRDO and Railway Ministry**. In this system, faecal waste will be stored in a close container and with the help of **bacterial inoculum**, organic waste will be converted into nutrient-rich liquid fertiliser and biogas with the use of the **anaerobic digestion** method. Many gases are generated in this process, like CH_4, NH_3, H_2S etc. It can also be used for industrial or domestic purposes for managing waste and/or to release energy.

In 2015 budget, the Government introduced bio-toilets in Indian trains with the allocation of ₹1000 crore. This was further extended in the constitutive year's budget plan.

Bio-Toilets can be Installed in Many Places

Himalayan region, Glaciers, Railways coaches, Buses, on Highways, Rural areas household, Educational institutions, Pilgrimage sites, etc.

Advantages of Bio-Toilets

- 100% sludge-free disposal of human waste or simply put, it eliminates the need for manual scavenging.
- Decomposition of solid waste to waste and biogas.
- Eco-friendly.
- Maintenance-free.
- Capable of functioning efficiently at sub-zero to –55°C.
- Plays a critical role in preventable health care, since the bio-toilets eliminate disease-causing pathogens completely.

Disadvantages of Bio-Toilets

- Bio-toilets system is very sensitive. It has more than 100% of chocking probability, due to disposal of napkins, cigarette buds, gutka pouches, liquor bottles etc.
- It is difficult to procure spares.
- Apart from these, the Indian government has taken it as a challenge to make India open defecation-free under the **Swachh Bharat Abhiyan** and various state governments are also working positively in this direction.

26.8 DRINKING WATER PURIFICATION / WATER PURIFIER

It is the process of eliminating undesirable chemicals, biological contaminants, suspended solids and gases from contaminated water.

Purified water may diminish the concentration of particulate matter, including suspended particles, parasites, bacteria, algae, viruses, fungi, as well as minimising the amount of a range of dissolved and particulate material derived from the surfaces that come from runoff water due to rainfall.

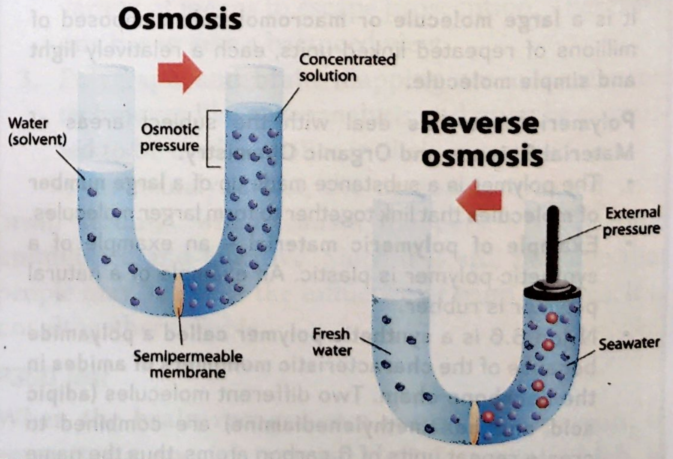
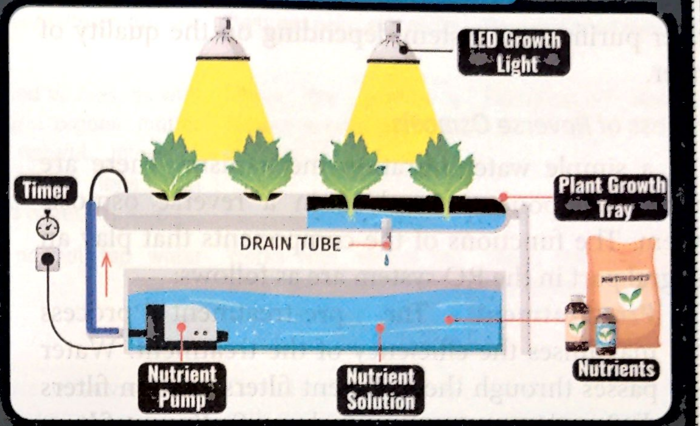


Figure 26.1
Process of Reverse Osmosis

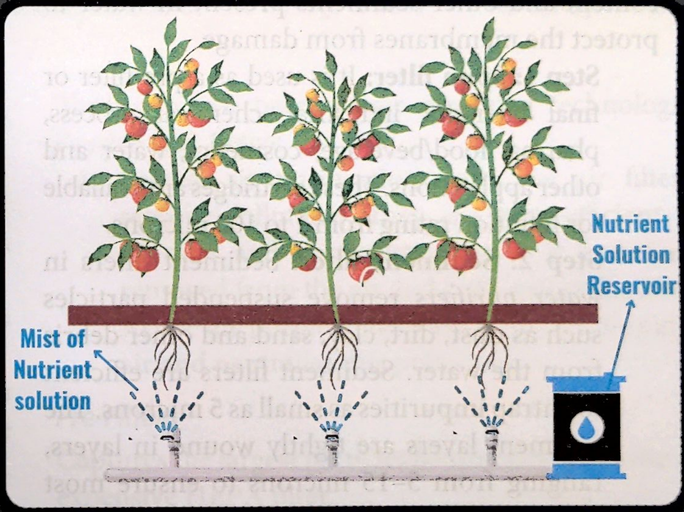
HYDROPONICS

- Hydroponics is a method of growing plants without soil, where plants are cultivated in a nutrient-rich water solution. Instead of relying on soil as a medium for plant growth, hydroponics uses various techniques to deliver the necessary nutrients directly to the plant roots in a controlled environment.
- In a hydroponic system, plants are typically grown in an inert growing medium, such as perlite, vermiculite, rockwool, or coco coir, which provides support to the roots. The plant roots come into direct contact with the nutrient solution, which is continuously circulated or periodically replenished to ensure the plants receive essential minerals and nutrients.
- Hydroponic systems can be set up in various configurations, including nutrient film technique (NFT), deep water culture (DWC), drip irrigation, and aeroponics. These systems can be implemented in small-scale indoor setups, greenhouses, or larger commercial operations.
- Advantages of Hydroponics:
  - Precise control over environmental factors
  - Faster growth rates and increased yields
  - Efficient resource utilization
  - Space efficiency
  - Year-round cultivation
  - Disease and pest control
  - Reduced environmental impact


LED Growth Light
Timer
Plant Growth Tray
DRAIN TUBE
NUTRIENTS
Nutrient Pump
Nutrient Solution
Nutrients

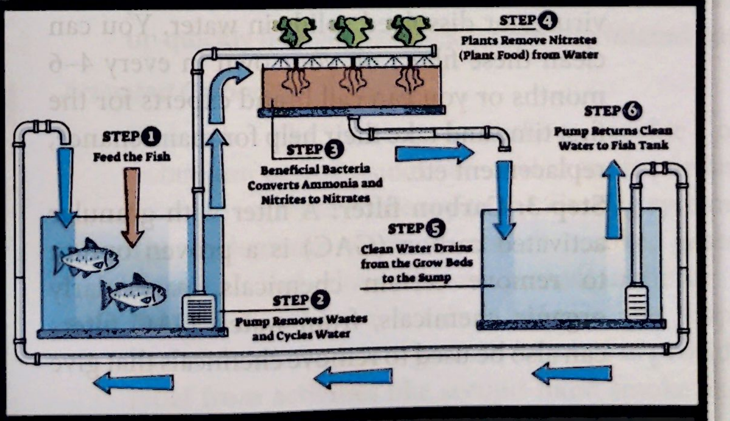
AEROPONICS

- Aeroponics is a type of hydroponic system where plants are grown in an air or mist environment without the use of a growing medium. In aeroponics, plant roots are suspended in the air, and a nutrient-rich mist or aerosol solution is applied directly to the roots at regular intervals.
- Unlike other hydroponic methods that use a growing medium to support the plants, aeroponics allows for maximum exposure of the roots to oxygen, promoting rapid growth and nutrient absorption.
- The mist nutrient solution is typically delivered through misters or sprayers, ensuring that the roots receive a fine and consistent nutrient mist.
- Aeroponic systems are also known for their space efficiency, as the absence of a growing medium allows for compact and vertical setups. This makes aeroponics particularly suitable for urban farming and indoor gardening, where space is limited.
- Overall, aeroponics offers a highly efficient and resource-saving method of plant cultivation, with benefits including accelerated growth, higher yields, and the ability to grow plants without the need for soil or a traditional growing medium.
- Advantages of aeroponics:
  - Faster growth and higher yields
  - Efficient nutrient uptake
  - Water conservation
  - Space efficiency
  - Reduced disease and pest issues
  - Resource efficiency
  - Versatile and scalable


Nutrient Solution Reservoir
Mist of Nutrient solution

AQUAPONICS

- Aquaponics is a sustainable farming method that combines aquaculture (fish farming) and hydroponics (soilless plant cultivation) in a symbiotic system.
- It involves the cultivation of fish and plants in a mutually beneficial relationship, where fish waste provides nutrients for the plants, and the plants filter the water for the fish.
- In an aquaponic system, fish are raised in a tank or pond. The fish produce waste in the form of ammonia-rich excretions. This waste would typically accumulate and become toxic to the fish in a traditional aquaculture setup. However, in aquaponics, the water containing fish waste is pumped into a hydroponic grow bed or raft system, where plants are grown.
- The plants, typically leafy greens or herbs, absorb the nutrients from the fish waste as they filter the water. Through a natural process called nitrification, beneficial bacteria convert the ammonia into nitrites and then into nitrates, which serve as a nutrient source for the plants. As the plants take up these nutrients, they help purify the water, removing harmful substances and providing clean, oxygenated water back to the fish.
- Advantages of aquaponics:
  - Sustainable and efficient
  - Dual harvest of fish and crops
  - Reduced environmental impact
  - Versatility and scalability
  - Educational and community benefits


STEP ④ Plants Remove Nitrates (Plant Food) from Water
STEP ① Feed the Fish
STEP ③ Beneficial Bacteria Converts Ammonia and Nitrites to Nitrates
STEP ⑥ Pump Returns Clean Water to Fish Tank
STEP ⑤ Clean Water Drains from the Grow Beds to the Sump
STEP ② Pump Removes Wastes and Cycles Water

There are different types of water filtration processes such as **reverse osmosis (RO)**, **ultrafiltration (UF)** and **ultraviolet** disinfection (UV). We should choose a water purification system depending on the quality of water.

Process of Reverse Osmosis

It is a simple water filtration mechanism. There are various components involved in a reverse osmosis system. The functions of the components that play an integral part in the RO system are as follows:

1. **Pre-treatment:** The pre-treatment process maximises the efficiency of the treatment. Water passes through the sediment filters, carbon filters during the pre-treatment phase. **Sediment filters** help in removing silt whereas **carbon filters** help in removing the organic impurities present in water. These filters help remove dirt, chlorine content and other sediments present in water to protect the membranes from damage.

   Step 1: Spun filter: It is used as a pre-filter or final filter for industrial, chemical process, pharma, food/beverage, cosmetics, water and other applications. These cartridges are available for filtration rating from 1 to 100 microns.

   Step 2: Sediment filter: Sediment filters in *water purifiers* remove suspended particles such as dust, dirt, clay, sand and other debris from the water. Sediment filters are efficient to entrap impurities as small as 5 microns. The sediment layers are tightly wound in layers, ranging from 5–15 microns to ensure most efficient filtration. It is not responsible for changing the taste or smell of water. It is one of the preventive filtration methods and does not remove chemicals, heavy metals, bacteria, viruses or dissolved solids in water. You can clean these filters on your own in every 4–6 months or you can call brand experts for the first time and take their help for maintenance, replacement etc.

   Step 3: Carbon filter: A filter with granular activated carbon (GAC) is a proven option to remove certain chemicals, particularly organic chemicals, from water. GAC filters can also be used to remove chemicals that give objectionable odours or tastes to water such as hydrogen sulphide (rotten eggs odour) or chlorine. However, other chemicals, like iron and nitrate, are not attracted to the carbon and are not removed.
2. **Treatment with RO: Reverse osmosis is the process of osmosis in reverse.** Whereas Osmosis occurs naturally without energy required, to reverse the process of osmosis you need to apply energy to the more saline solution. A reverse osmosis membrane is a semi-permeable membrane that allows the passage of water molecules but not the majority of dissolved salts, organics, bacteria and pyrogens. However, you need to 'push' the water through the reverse osmosis membrane by applying pressure that is greater than the naturally occurring osmotic pressure in order to desalinate (demineralise or deionise) water in the process, allowing pure water through while holding back a majority of contaminants. Desalination is the process of removal of salt from seawater. Many water treatment plants now started using this reverse osmosis technique to deal with many water-related issues.

Ultraviolet Disinfection

Ultraviolet disinfection usually involves a UV lamp. UV lamp provides pure and safe drinking water. The UV light used in this process is a high powered UV which is also known as UV-C or germicidal UV. UV-C rays penetrate into the body of pathogens to deactivate them. The UV rays modify the DNA of the pathogens in such a way that they cannot multiply. These rays have the ability to kill 99.9% of the microorganisms.

Ultrafiltration (UF)

Ultrafiltration process uses hydrostatic pressure to force water against a semi-permeable membrane. This semi-permeable membrane helps in removing bacteria and different types of microorganisms and bad odour in the water. Ultrafiltration system helps in **removing colloids, bacteria, pathogens and other molecules that are larger than the size of the pores in the semi-permeable membrane.**

Ultrafiltration is not very different from **reverse osmosis, microfiltration (MF) or nanofiltration (NF)**, except in terms of the size of the molecules it retains.

TABLE 26.1 RO vs NF vs UF vs MF

Feature	RO Purification	NF Purification	UF Purification	MF Purification
Need for electricity	Purification necessitates the use of electricity	Purification necessitates the use of electricity	Does not need electricity	Does not need electricity
Extent of filtration	Filters the water to remove all bacteria and viruses	All bacteria and viruses, as well as most natural organic matter and some natural minerals, including divalent ions that generate hard water, are killed	Filters the water to remove all bacteria and viruses	Filters out only bacteria
Water pressure	High water pressure is required. As a result, all RO systems have an additional water pump	Works with normal tap water pressure	Works with normal tap water pressure	Works with normal tap water pressure
Impact on dissolved salts and harmful metals	Removes dissolved salts and harmful metals	Cannot remove dissolved salts and harmful metals	Cannot remove dissolved salts and harmful metals	Cannot remove dissolved salts and harmful metals
Size of membrane	0.0001 micron	0.01 micron	0.01 micron	0.1 micron
TDS reduction (in %)	90%	80–89%	0%	0%
Wastage of water	Wastes water but it can be reused	Wastes a lot of water but it can be reused.	No wastage of water	No wastage of water

26.9 AIR CLEANERS AND AIR PURIFIERS

Air Purifier

- Dust, pollen, pet dander, mould spores and dust mite faeces can act as allergens, triggering allergies in sensitive people.
- Smoke particles and volatile organic compounds (VOCs) can pose a risk to health.
- Exposure to various components such as VOCs increases the symptoms of sick building syndrome (which can cause headaches, dizziness, nausea, and eye, ear and nose irritation).
- In the 1950s, HEPA filters were commercialised, as main air-purifier filter.

Purifying Technologies

TABLE 26.2 Technologies Developed for Air Purification

Technologies	Pros	Cons
Pre-filters	• Captures large particles • May be washable • Extends life of HEPA filter	Requires maintenance
Activated carbon	• Absorbs odours, gases, and chemicals • Leaves space, smelling fresh • Removes tobacco smoke and pet odours	Heavy expensive
Ultraviolet light	• Neutralises microorganisms, like bacteria and viruses	

There are two types of air purifying technologies – Passive and Active.

1. Passive air purification units use air filters to remove pollutants. They are more efficient since all dust and particulate matter is permanently removed from the air and collected in the filters.
2. Active air purifiers use ionisation for cleaning the air and neutralise this pollution.

Pre-Filters

Captures the largest particles before they reach the more expensive HEPA filter.

- Most of the particles in air are large particles like dander and dust, not tiny ones like pollens and microbes.
- Even though HEPA filters have a large number of pleats to maximise their surface area, they can fill up quickly if larger particles are not pre-filtered out.

Activated Carbon

- Elements like activated carbon, zeolite or potassium permanganate are added to air purifier filters to increase efficiency to the filtering system.
- These elements work to absorb smoke, gases, chemicals and odours that are present in the air.
- Activated carbon neutralises odours and traps harmful chemicals and gases in its pores to provide relief from activities like second-hand smoke and harmful fumes produced from renovations.

- An effective filtering system that is also equipped with chemical adsorption materials can produce cleaner and fresher-smelling air.

Ultraviolet Light

- Ultraviolet light (UV) technology is key to neutralising viruses and bacteria that accumulate on air purifier air filters.
- It is important to use the UV technology in combination with HEPA air filters and possibly activated carbon.
- Without a particulate filter system like a HEPA air filter, too many microorganisms may be hidden from the UV light, since it is not easily located on an air filter.

TABLE 26.3 Types of Air Purifier

Air Purifier	Pros	Cons
HEPA air purifiers	• Most effective technology for air purifiers • Removes up to 99.97% of particles that pass through, like allergens, pollen, dust, dander and others that are 0.03 microns and larger in size • Used worldwide in medical cleanrooms	• Regular filter replacements
Electrostatic air purifiers	• No air filter replacement necessary	• Removes only 30% of particles from the air • Does not clean all of the air in an enclosed space • Does not use HEPA air filters
Ozone generator	• Removes strong odours • Kills bacteria, mould and other microorganisms	• Extremely dangerous lung irritant • California Air Resources Board restricts technology sold in the state of California

A HEPA filter is made up of a mat of randomly arranged fibres.

High efficiency particulate air (HEPA), originally called high-efficiency particulate absorber but also sometimes called high-efficiency particulate arresting or high-efficiency particulate arrestance is a type of air filter.

26.10 SAFETY ON WHEELS

The highest numbers of deaths in road accidents were reported on the National Highways accounting for 34.5% (53,615 out of 1,55,622) followed by State Highways (25.1%) (39,040 deaths). A total of 62,967 (40.5%) persons died due to road accidents on the other roads during 2021. The United States of America has a distinguished record of the highest number of road accidents in the world.

There are two types of safety features in vehicles:

1. **Passive safety features:** **Airbags** are an example of 'passive safety features', which prevent or minimise injury to the passengers in a crash.

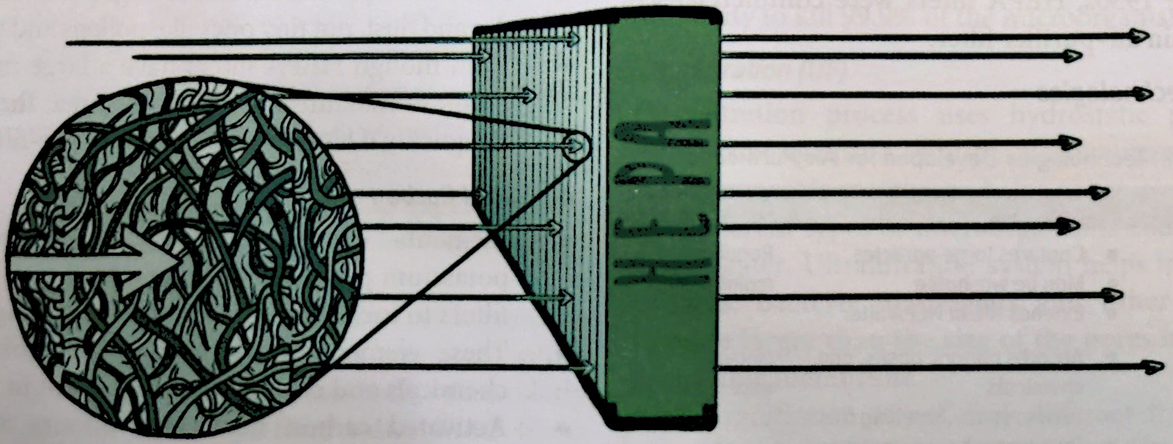


Figure 26.2
HEPA Filter

Principle of airbag: Generally **accelerometer** is required. It is responsible for detection of car crash/collision which results in the deployment of airbags almost **instantaneously [1/10 of second (30 milliseconds)]**.

2. **Active safety features:** Safety features in a vehicle that help prevent a crash by providing the driver with better ways of controlling the vehicle and avoiding hazards are called 'active safety features'. Anti-lock breaking system, electronic stability control and automatic braking are some examples of 'active safety features'.

6.10.1 Different types of Active Safety Features in Vehicle

1. **Anti-Lock Braking System (ABS):** Skidding is the phenomenon of locking up the wheels of a vehicle when a sudden or extreme braking force is applied. When the front wheel(s) of a vehicle are locked, its ability to change direction is reduced.
2. **Autonomous Emergency Braking (AEB):** A number of crashes are caused due to late braking and/or braking with insufficient force. A driver may brake too late for several reasons: he/she is distracted or inattentive; visibility is lower, for instance when driving in heavy fog, rain or snow; or in unpredictable situations, when the driver ahead brakes unexpectedly.

   Most AEB systems use radar, stereo camera and/or LiDAR (Light Detection and Ranging)-based technology to identify potential collision objects in front of the car.

   If a potential collision is detected, generally AEB systems first try to alert the driver that an emergency action is needed. If still no action is taken and a collision is imminent, the system will then apply the brakes.
3. **Lane Departure Warning System:** Lane departure warning system warns the driver when the car is getting close to a lane marking. The type of warning can be different, depending on the system. While some systems give an audible signal, others produce a vibration in the steering wheel to simulate the feeling of the car running over a 'rumble strip'.

   A camera is usually situated at the top of the windscreen behind the rear-view mirror.
4. **Heads up Display:** HUD or heads up display is a **digital transparent display that is projected onto the windshield** (front mirror to save against air pressure) which takes their eyes on the road. This technology was initially developed especially for aircraft pilots, and for military aviation.
5. **Hill Start Assist/Hill Control:** The hill start assist is a system that prevents the car from rolling down the slope while the driver **known as 'handbrake hill start'**, in which the driver engages the handbrake of the car momentarily, while pulling away on an inclined surface.
6. **Electronic Stability Programme (ESP):** It monitors the wheel speed sensors, steering wheel angle, lateral acceleration, yaw rate etc., to **detect if the driver is losing control**. ESP employs in tandem, ABS, electronic brake force distribution (EBD), traction control system (TCS) and active yaw control (AYC) to **stabilise the vehicle and keep it on the road.**
7. **Pedestrian Airbag:** Volvo is the first company to introduce 'pedestrian airbag', a technology first used in their **Volvo V40**. The 'pedestrian airbag' is probably the only one-of-its-kind feature that offers protection to the pedestrian, and also minimises impact forces and resultant injuries.

   The airbag is designed to protect pedestrians from accidental injuries at city speeds, from around 12 miles per hour to 31 miles per hour.
8. **Cruise Control:** Often, over long distances, driver's fatigue leads to vehicle crashes. Cruise control is a system that **automatically controls the speed of a vehicle on long stretches of highways with constant flow of traffic.** The purpose of cruise control is to accurately maintain a speed set by the driver, without any outside intervention by controlling the throttle–accelerator pedal linkage.
   - ***Dynamic cruise control:*** It is not exactly a **collision avoidance system,** but only serves to **maintain a desired vehicle speed** as set by the driver (constant traffic).
   - ***Adaptive cruise control:*** With the number of cars on roads increasing exponentially, the functionality of normal (dynamic) cruise control is becoming obsolete. It lets the car hold a speed but allows adjustment based on **changing traffic with the help of automatic**

braking and acceleration. A radar sensor continuously monitors the distance to the vehicles in the front and automatically adjusts speed to maintain a proper safe distance, thus preventing rear-end collisions (variable traffic).

ADAS: ADVANCED DRIVER-ASSISTANCE SYSTEMS

ADAS are electronic systems in a vehicle that use advanced technologies to assist the driver. They can include many active safety features, and often the terms 'ADAS' and 'active safety' are used interchangeably.

ADAS technology uses sensors, cameras and radar among other systems to monitor the environment around a vehicle. Based on this, ADAS provides drivers with real-time information and alerts to help them avoid collisions and other potential hazards. Autonomous application solutions are partitioned into various chips, called systems on a chip (SoCs). These chips connect sensors to actuators through interfaces and high-performance electronic controller units (ECUs).

Self-driving cars use a variety of these applications and technologies to gain 360-degree vision, both near (in the vehicle's immediate vicinity) and far.

Essential safety–critical ADAS applications include:

- Pedestrian detection/avoidance
- Lane departure warning/correction
- Traffic sign recognition
- Automatic emergency braking
- Blind spot detection

These life-saving systems are key to the success of ADAS applications. They incorporate the latest interface standards and run multiple vision-based algorithms to support real-time multimedia, vision co-processing and sensor fusion subsystems.

26.11 WIRELESS TRANSMISSION OF ELECTRICITY, WITRICITY AND WIRELESS CHARGING

Wireless power transfer (WPT) has become very important nowadays, as portable technology has become a part of everyday life.

The founder of AC electricity, 'Nikola Tesla', was the first to conduct experiments dealing with wireless charging and accomplished a major breakthrough by transmitting 10^8 volts of high-frequency electric power over a distance of 25 miles to light 200 bulbs and run an electric motor.

In 1901, Tesla constructed the **Wardenclyffe Tower** to transfer electrical energy between America and Europe through the **Ionosphere**. The Tesla Tower was about 185-feet high, with a well about 100-feet deep, for use in experimenting with the transmission of electrical energy for power and lighting purposes through wireless medium.

The equipment cost was nearly $200,000. However, due to technological limitations (e.g., low system efficiency due to large-scale electric field), the idea has not been further developed and commercialised.

Later, during the 1920s and 1930s **magnetrons** were invented to convert electricity into microwaves, which enable wireless power transfer over long distances. However, there was no method to convert microwaves back to electricity. It was only in 1964 when W. C. Brown, regarded as the principal engineer of practical wireless charging, realised the conversion of microwaves to electricity through a **rectenna** or **a rectifying antenna (Witricity).**

Wireless power transfer (WPT), using **magnetic resonance technology** that adopts the same basic theory that has already been developed for at least 30 years with the term inductive power transfer. At kilowatts power level, the transfer distance increases from several millimetres to several hundred millimetres with a grid-to-load efficiency above 90%. These advances make WPT very attractive for electric vehicle (EV) charging applications in both stationary and dynamic charging scenarios. The magnetic wireless power transfer over a distance of 6.5 feet can deliver 10 kilowatts of electric power with a coil-to-coil stationary efficiency of 97%.

Wireless Charging Technologies

The development of wireless charging technologies is advancing towards two major directions. **'Radiative wireless charging' using radio frequency (RF) or microwaves is used for long-distance transmission of power.** Due to the safety issues raised by RF, exposed radiative wireless charging usually operates in a low-power region.

'Non-radiative wireless charging' (or coupling-based wireless charging) is **based on the coupling of the magnetic field between two coils within the distance of the coils'** dimension for energy.

It involves inductive coupling, **magnetic resonance** coupling and capacitive coupling. Due to safety implementation, non-radiative wireless charging has been widely used in our daily appliances.

Inductive charging: Most of today's wireless chargers use 'inductive charging' with transmit and receiver coils in close proximity (only few centimetres). The action of an electrical transformer is the simplest instance of wireless energy transfer via induction. The transfer of energy takes place by electromagnetic coupling through a process known as mutual induction.

In resonance charging, the transfer efficiency and power transferred are a little lower compared to induction charging, but the transfer distance can be in metres.

'Radiate wireless power transfer' is used to transfer large amounts of power over long distances through space, by means of microwaves. A **microwaves power transfer (MPT)** system converts direct current (DC) power to microwaves, transmits the microwave radiation to a receiver, which then converts the microwave radiation back to DC power.

26.12 CYBERNATIC ORGANISM (CYBORG)

The term 'Cyborg' was first coined in 1960 by Manfred Clynes and Nathan S. Kline to **describe man–machine systems** in which the control mechanisms of the human portion are modified externally by drugs or regulatory devices so that the being can live in an environment different from the normal one; for example, in an extra-terrestrial being.

Cyborg, short for **'cybernetic organism',** is no longer an imaginary organism but an organism with organic and **biomechatronic body parts,** that is **partly human and partly machine**. They include people with cochlear implants, cardiac pacemakers, contact lenses or implants that make life easier for humans.

The Cyborgs

In 1997, **Philip Kennedy,** a scientist and physician, created the **world's first human cyborg** from Johnny Ray, a Vietnam veteran who suffered a stroke. Ray's body, as doctors called it, was 'locked in'. Kennedy embedded an implant he designed (and named 'neurotrophic electrode') near the part of Ray's brain so that Ray would be able to have some movement back in his body. The surgery went successfully, but in 2002, Johnny Ray died.

In 1998 Kevin Warwick, former Professor of Cybernetics at the University of Reading, initiated a series of pioneering experiments *involving the neurosurgical implantation of a device into the median nerves of his left arm in order to* **link his nervous system directly to a computer.**

In 2004, Neil Harbisson (**Fig. 26.3**), an artist born with achromatopsia or extreme colour blindness, **permanently attached an antenna inside his skull.** He is the first human to be described as a Cyborg by any government.

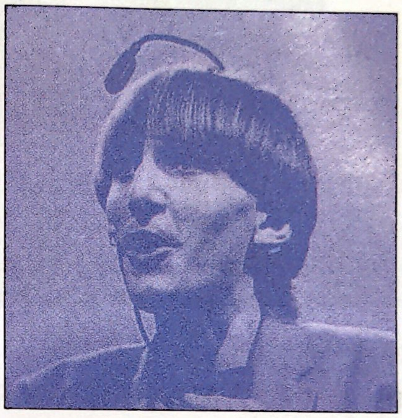


Figure 26.3
Neil Harbisson with an Implanted Antenna

The Future

The practice of integrating technology with the human body is happening more often and beyond the medical field; perhaps, setting the stage for the next chapter in human evolution. Many researchers believe that we have already started down the path towards a Cyborg future; after all, many of us already depend on **bionic ears and eyes, insulin pump technology and prosthetics to help us survive.**

In 2016, the first Cyborg Olympics were **celebrated in Zurich Switzerland. 'Cybathlon' 2016 was the first Olympics for Cyborgs and the first worldwide and official celebration of Cyborg sports.** In this event, 16 teams of people with disabilities used technological developments to turn themselves into Cyborg athletes.

SpaceX and Tesla's CEO, Elon Musk is backing a brain–computer interface venture called Neuralink. With Neuralink, Musk hopes to develop a micron-sized device to help link brains and machines, and

treat brain injuries and their symptoms, such as strokes, paralysis and even memory loss in old age.

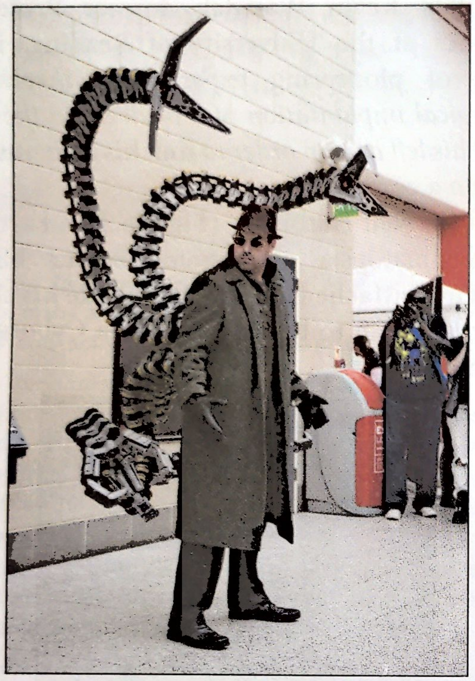


Figure 26.4

Doctor Octopus, a character from Spiderman movie, posing at the MCMExpo at the Excel Centre

26.13 INCANDESCENT BULB, CFL (COMPACT FLUORESCENT LAMPS) AND LED (LIGHT-EMITTING DIODE)

26.13.1 Incandescent Bulb

It refers to the conversion of heat to light, which requires the filament inside an incandescent lamp to burn at a high temperature (350°F or 176°C). This conversion is very simple but the disadvantages are that only 5% of the total energy consumed by the lamp is used to generate light (95% is wasted as heat) and the lifetime is limited to about 2,000 hours.

26.13.2 CFL (Compact Fluorescent Lamps)

Fluorescence is the conversion of ultraviolet (UV) light to visible light. Electrons flow through the fluorescent lamp and collide with mercury atoms, causing photons of UV light to be released. The UV light is then converted into visible light, as it passes through the phosphor coating on the inside of the glass tube. This two-stage conversion process is much more efficient than incandescent lamp process, resulting in 25% of the total energy consumed used to generate light, lower lamp temperatures (40°C) and longer lifetime (10,000 hours).

Environmental Impact

CFLs contain toxic chemicals, unlike incandescent lamps. The mercury present in CFLs has been one of the most talked-about issues related to compact fluorescent light bulbs. Each contains about 4 milligrams of mercury, which is a cumulative poison. But because coal also contains mercury, which is released into the atmosphere when burned, this too is a source of mercury pollution. If we assume that all our electricity came from coal, then the amount of mercury pollution saved by switching to CFLs is about double that in the lamps themselves so their use could reduce the net mercury burden on the environment. CFLs are designed to operate within a specific temperature range. Temperatures below the range cause reduced output. There can also be problems with local pollution if they are not properly disposed.

CFLs Emit UV

All fluorescent lamps are known to emit some UV. Typical fluorescent lamps, which include CFLs, which consumers would encounter, emit very low levels of UV. In order to measure any UV radiation from these lamps, very sensitive measuring equipment must be used.

Note: CFL emits both ultraviolet and visible light but LED emits only visible light, so LED does not have an adverse effect on human health.

26.13.3 Light-Emitting Diodes (LED)

LED lighting products produce light up to 90% more efficiently than incandescent light bulbs. An electrical current passes through a microchip, which illuminates the tiny light sources we call LEDs and the result is visible light.

A light-emitting diode (LED) is a semiconductor device that emits light when an electric current flows through it. When current passes through an LED, the electrons recombine with holes emitting light in the process.

LEDs allow the current to flow in the forward direction and blocks the current in the reverse direction.

The colour of an LED is determined by the material used in the semiconducting element. The two primary materials used in LEDs are aluminium gallium indium phosphide alloys and indium gallium nitride alloys. Aluminium alloys are used to obtain red, orange and yellow light, and indium alloys are used to get green, blue and white light. Slight changes in the composition of these alloys change the colour of the emitted light.

Blue LED

Exposure of blue light can cause permanent damage to the retina. Light-induced retinal damage can result from viewing either a very bright light for a short time (acute exposure) or a less bright light for a longer duration (development of age-related macular degeneration – AMD).

Blue LED light is most often used to treat acne. It may do this by reducing activity in the sebaceous glands, so they produce less of the oil that can plug the hair follicles, leading to acne. Blue light may also kill acne-causing bacteria known as Cutibacterium acnes.

In 2014, **Shuji Nakamura, Isamu Akasaki** and **Hiroshi Amano** were awarded the Nobel Prize in physics for their invention of blue LED, which made it possible to light **flat screen TVs, computer monitors, smart phones** and **tablets**. LED technology takes less energy and emits less heat, making it an ideal lighting source to save money and energy.

Sodium Lamp vs LED lights

- Sodium lamps provide 360 degree light emitting. Whereas LED lights tend to direct light downward, rather than a full 360 degrees.
- Monochromatic light means that the light has a single wavelength. The LED light is not monochromatic because it is made up of different wavelengths, therefore is polychromatic. Often, a combination of wavelengths is used to create different colours.
- LEDs last longer than any light source commercially available in the market.

TABLE 26.4 Comparison among Incandescent Bulb, CFL and LED

	Incandescent Light Bulbs	Compact Fluorescence Lamp (CFL)	LED
Lifespan (average)	1,200 hours	8,000 hours	50,000 hours
Watts of electricity used (equivalent to 60-watt bulb)	60 watts	13–15 watts	6–8 watts
Kilowatts of electricity used	3285 kWh/year	767 kWh/year	329 kWh/year
Turns on instantly	Yes	No, it takes time to warm up	Yes
Durability	Not very durable – glass or filament can break easily	Not very durable – glass can break easily	Very durable – LEDs can handle jarring and bumping
Heat emitted	Maximum	Intermediate	Minimum
Greenhouse gas emission	Maximum greenhouse gas emission	Intermediate level of greenhouse gas emission	Minimum greenhouse gas emissions

26.14 HIGH-SPEED TRAIN: BULLET TRAIN, MAGLEV (MAGNETIC LEVITATION) AND HYPERLOOP

26.14.1 Bullet Train

A bullet train is not an official word used for high-speed railways, it is only the unofficial name of first high-speed train of Japan. A high-speed rail can be defined as a train that operates at a minimum speed of 200 km per hour on tracks built specially for high-speed travel.

On the basis of technology employed in the trains, it can be **classified into two categories:**

1. Tilt technology
2. Non-tilt technology

Tilt technology: The trains based on this technology are known as tilting train. They have the capability to tilt their body towards the curve. This tilt allows the train to pass the curve at a higher speed. It may run at a speed of 200 km per hour for upgraded track and 250 km per hour or even faster for a new track. This technology is expensive and can generally function at larger passenger base regions.

Non-tilt technology: The trains based on this technology run on straight special tracks or tracks with large curve radius. Exclusive tracks are laid down which provide higher level of passenger comfort. Trains can run at 250 km per hour or more speed on such tracks. This technology provides high efficiency of rail freight transport.

Foundation Stone for Bullet Train in India

India's first high-speed rail project (bullet train) project was jointly laid by Prime Minister Narendra Modi and his Japanese counterpart, Shinzo Abe at Sabarmati Station Ground in Ahmedabad in 2017. The 508 km-long, **Mumbai to Ahmedabad High Speed Rail (MAHSR) Project** would be built at a cost of 1.10 lakh crore. It was expected to be completed by 2022 (It was recently preponed by a year from the earlier deadline of 2023), but now it's delayed.

NEW UPDATES

India's Bullet train will run by August 2026: Ashwini Vaishnaw

India's first bullet train is slated to run in August 2026 with a larger section planned for the year after, said Railways and Telecom Minister Ashwini Vaishnaw, noting that the project will give a boost to the economy, as many of the companies supplying to the project had started getting export orders **(14 March 2023).**

1. MAHSR project is a joint venture between **Indian Railways** and **Japan's Shinkansen Technology**.
2. The train will cover a distance of over 508 km from **Sabarmati (Gujarat) to Bandra (Mumbai, Maharashtra)** in around 2.58 hours at high speed of approximately 320 km per hour from the existing 7–8 hours. On the Ahmedabad–Mumbai route, **12 stations have been proposed**: Mumbai, Thane, Virar, Boisar, Vapi, Bilimora, Surat, Bharuch, Vadodara, Anand, Ahmedabad and Sabarmati (four stations in Maharashtra and eight stations in Gujarat).
3. As per plan, the entire corridor will be on elevated track, except 21 km, which will be underground; of which, 7 km will pass under the sea **(under water train in the world – the United States, Russia, Japan and China).**
4. Of the total project cost of 1,10,000 crore, 80% – 88,000 crore – will be provided by **Japan International Cooperation Agency (JICA)** as soft loan at an interest of 0.1% per annum. This loan will be repaid to Japan in 50 years, with 15 years grace period. The breakup of the cost has been finalised as **25% by Maharashtra, 25% by Gujarat and 50% by the Centre**. It has a proposed speed of approximately 320 km per hour with a train capacity of 900 to 1200 passengers.
5. **High Speed Rail Corporation of India Limited (HSRC):** It has been formed on the directions of the Ministry of Railways, Government of India, for the development and implementation of high-speed rail projects.
6. The success of this project, however, will lie in its execution. Its successful and timely completion could act as a powerful catalyst to create a culture of efficient project implementation in India. Similarly, there should be a focus on leveraging the post-implementation synergies, which could make this a transformational project for India.

How this project helps in India's growth

- New production bases and townships will eventually expand along the MAHSR.
- Construction activity will boost allied industries such as steel, cement and infrastructure.
- New temporary and permanent jobs.
- Managing a project of this complexity and scale will be a great learning experience for the Indian agencies involved.

Way Ahead

The success of this project, however, will lie in its execution. Its successful and timely completion could act as a powerful catalyst to create a culture of efficient project implementation in India. Similarly, there should be a focus on leveraging the post-implementation synergies, which could make this a transformational project for India.

26.14.2 Maglev Technology

It is a new version of bullet trains or high-speed trains, based on magnetic levitation. They are levitated, propelled and guided by using magnets. The friction, energy consumption and the noise production are almost zero. This is a highly energy efficient and comfortable version of high-speed trains. Maglevs do not need maintenance frequently because wheels and the rails do not wear out. These trains uplift and move on track in friction-less condition, so speed can be easily increased. Attractive and repulsive forces are required to set the train in motion. Two types of Maglev trains are:

1. Electromagnetic propulsion
2. Electrodynamic suspension

Electrodynamic suspension train is now running in Japan with metal-based superconductor used. Metal at −278°C becomes superconductor and resistance becomes approximately zero. This bullet train is faster and its speed is around 601 km per hour.

TABLE 26.5 Difference between Bullet Train and Maglev

Maglev Train	Bullet Train
Does not need wheels	May or may not need wheels
Produces very low noise	Noise is a major issue
Highest energy efficiency	Is more efficient than conventional trains
Capital cost is very high	Less expensive than Maglev
Technology available in a few countries	Available is most developed countries

26.14.3 Hyperloop Technology

Hyperloop envisages pods or capsules travelling at high speeds through low-pressure tubes erected on columns or tunnelled underground. The system is fully autonomous and sealed, so no driver-related error is anticipated. In a sealed environment with almost no air resistance, the pods are expected to reach very high speeds.

Mechanism of Hyperloop Train

How to maintain good speed

1. **Decrease air density** in hyperloop train so air resistance become very less.
2. In front of the train, we will use an **air compressor fan,** which will reduce air pressure.
3. **Air bearing** is required to remove air outside.

Hyperloop in India

In 2018, the Maharashtra government signed an MoU with **British Virgin Group** to build the Mumbai–Pune hyperloop. The proposed hyperloop for Pune and Mumbai will link central Pune, Navi Mumbai International Airport and Mumbai in 25 minutes.

This system will connect 26 million people and support 150 million passenger trips per year. The Pune–Mumbai route could result in $55 billion (350,000 crore) in 'socio-economic benefits, time savings, accident reduction and operational cost savings, over 30 years of operation'. The route will be 100% electric and could reduce greenhouse gas emissions by up to 86,000 tonnes over the next 30 years.

India's First Hyperloop to Connect Amaravati and Vijayawada

- **The US-based Hyperloop Transportation Technologies Inc. (HTT)** is gearing up to roll out India's first hyperloop project, connecting **Vijayawada and Andhra Pradesh's capital Amaravati.**
- Hyperloop, which uses a low-pressure tube to transport people at speeds as high as 1,200 km per hour, will cut down the nearly one-hour travel time for the Vijayawada–Amaravati ride to just around 5–6 minutes.
- According to sources, the project, to be taken up on a public private partnership (PPP) mode, will cost around $200–250 million (₹1,300–1,600 crore) and create over 2,500 jobs. Andhra Pradesh Economic Development Board (APEDB), along with the AP government, will assist HTT with all regulatory requirements, and develop and implement the hyperloop project in Amaravati.

Hyperloop concept was firstly proposed by **Elon Musk, the CEO of SpaceX and Tesla,** in 2012. It should be noted that Musk is no longer directly involved in the development of this technology. Musk originally estimated that a route from **Los Angeles to San Francisco** would cost about $6 billion, or approximately $11.5 million per mile. But leaked documents from Hyperloop One (seen by Forbes) put that cost to $13 billion, or $121 million per mile.

Besides that, it still faces technological and regulatory hurdles, and several issues related to ownership of land that could slow down the prospects of setting up a hyperloop transportation system. Compressor fan and electromagnetic motor will further reduce the speed of train.

HYPERLOOP IN WORLD

1. **World's first hyperloop train** route will be built between Toronto and Montreal, Canada. (Note: Faster than passenger planes) **Toronto to Montreal** (640 km) will be covered in 39 minutes.
2. Los Angeles-based hyperloop: One has chosen two largest Canadian metropolitan areas for **world's first hyperloop commercial service**. **Los Angeles to San Francisco** would take just 50 minutes.
3. Other cities are also looking to set up hyperloop services. United Arab Emirates plans to build a hyperloop connection between **Abu Dhabi** and **Dubai**, two largest centres in terms of population in Emirates. These two cities are 150 km apart; hyperloop will cover this distance in 12 minutes and could be built as early as 2022.

26.14.4 Vande Bharat (VB)/Train 18

It is India's first indigenously built engineless semi-high speed train. Earlier, it was known by the name **Train 18**. It runs between Delhi and Varanasi at a maximum speed of 160 kmph.

- The Train 18, later named **Vande Bharat Express**, was rolled out by the Integral Coach Factory, Chennai, under the Indian government's 'Make in India' initiative.
- The train was launched on **15 February 2019**.
- As of **May 2023**, the Indian Railways operated **19 Vande Bharat trains** in India.
- Vande Bharat trains are self-propelled 'engineless' train sets.
- Its faster acceleration and deceleration results in reduced train travel time.
- Some of its passenger-friendly features include: European-style seats, diffused LED lighting, GPS-based infotainment systems, modular bio-toilets, fully sealed gangways for dust-free environment, centrally controlled entry/exit doors with sliding footsteps, divyang-friendly toilets and automatic sliding cabin doors.
- The Indian Railways plans to operate 102 Vande Bharat trains by March 2024.

TABLE 26.6 Vande Bharat have different variants VB1.0, VB2.0, VB3.0 and VB4.0

Features	VB1.0	VB2.0	VB3.0	VB4.0
Exterior	**Aerodynamic design**	**Aerodynamic design**	**Aerodynamic design**	**Aerodynamic design**
Made up of	**Stainless steal**	**Stainless steal**	Half of the VB3 train sets will have coaches made of steel, while the other half will have coaches made of aluminium with articulated bogies.	**Aluminium alloys**
Facility	GPS-based passenger information system, bio-vacuum toilets, rotational seats	• **Ditto** • The VB2 is additionally equipped for safety and protection with **Kavach signalling technology (anti-collision system)**	• Ditto • VB3 is expected to be lighter and more energy efficient than the VB2, as well as have better passenger amenities.	Improved passenger amenities such as a 3-pin socket and USB power socket for every passenger, zero discharge toilet systems, and facilities to accommodate passengers travelling in wheelchairs.
Speed performance	The Vande Bharat can reach a maximum speed of 180 km/h. It can accelerate to a speed of 100 km/h in 54.6 seconds and reach its maximum speed in 145 seconds.	The VB2 trains can accelerate to a speed of 100 km/h in 52 seconds, compared to the 54 seconds taken by the older version. The train can reach a speed of 160 km/h in 140 seconds, 5 seconds faster than the first generation of the Vande Bharat.	VB3 is expected to have a maximum speed of 180–200 km/h and a design life of 35 years. **It will come soon in service.**	VB4 is planned to have a maximum speed of more than 200 km/h. All VB4 train sets are expected to be **tilting trains**, marking the first commercial deployment of the technology in India. The first VB4 set is **expected to enter service in 2024**.
Facility	Sitting coaches only	Sitting coaches only	**Sleeper coaches will start**	**Sleeper coaches will continue**

26.15 INDIAN RESEARCH CENTRE IN ANTARCTICA AND ARTIC

26.15.1 Antarctica Research Centre

Antarctica is the fifth largest continent in the world, which is isolated, fully covered with snow and has the cleanest air in the world. The activities in Antarctica are regulated by Antarctica Treaty, 1959. It plays a significant role in all types of scientific researches because of its unique and untouched oceanic and climatic atmosphere.

Indian research stations in Antarctica are established under Indian Antarctic Programme. This programme was governed by National Centre for Antarctic and Ocean Research, Ministry of Earth Sciences and Government of India.

Dakshin Gangotri: In 1984, India established its first research station in Antarctica. It was located at approximately 2,500 km from the South Pole. It was later destroyed completely.

Maitri: It was the second permanent station of India in Antarctica, established in 1987. It was located on the rocky mountainous region called Schirmacher Oasis. India also built a freshwater lake around Maitri, known as Lake Priyadarshini.

Bharti: It was established in 2012. It is equipped with all the research facilities. Bharti is located at 3,000 km east of Maitri and was constructed using 134 recycled ships. It is a comfortable station and can accommodate up to 25 scientists.

26.15.2 IndARC (India's Arctic Observatory)

It is an Indian Arctic Observatory, which will be helpful to scientists in **understanding the Arctic climate and its influence on the Indian monsoon system.**

The deployment of IndARC, **the country's first underwater moored observatory in the Kongsfjorden fjord, half-way between Norway and the North Pole, represents a major milestone in India's scientific endeavours in the Arctic region.**

It was designed and developed by scientists from the Earth System Science Organisation (ESSO), National Centre for Antarctic and Ocean Research (NCAOR), National Institute of Ocean Technology (NIOT) and Indian National Centre for Ocean Information Services (INCOIS).

The observatory is anchored at a depth of 192 metres and has an array of 10 state-of-the-art oceanographic sensors, strategically positioned at various depths in the water. Certain sensors were programmed to collect real-time data on seawater temperature, salinity, ocean currents and other vital parameters of the fjord.

The Kongsfjorden is considered as a natural laboratory for studying the Arctic climate variability. Scientists predict that melting of the Arctic glaciers will trigger changes in weather patterns and ocean currents that could affect other parts of the world. It will be helpful to understand 'the interaction between the Arctic ice shelf and the deep sea and its influence on climate shift that requires detailed studies over an annual seasonal cycle'. One of the major constraints in such a study has been the difficulty in reaching the location to collect data during the harsh Arctic winter. The IndARC observatory is an attempt to overcome this lacuna.

26.16 TELEVISION TECHNOLOGY: CRT, LCD, PLASMA, LED, OLED AND QLED

Television (TV) is a communication medium for transmitting and receiving moving images with or without accompanying sound. The word television came from **Greek words – tele and vision**. Tele means '**distant**' and vision means '**sight**'.

There are different types of transmission modes in communication and information systems used. Transmission mode or communication mode is transferring of data between two devices. These are always in the direction of flow of information.

There are three types of transmission modes:

(A) Simplex Mode

- Message sources are always transmitter and the destination source is receiver. In simplex mode, the direction of transmission is unchanging (from one antenna to the other only).
- A **radio station** and **television setups** are always a simplex channel because it always transmits the signal to its listeners and never allows them to transmit back.

- The advantage of simplex mode of transmission is that the entire bandwidth can be used because **data transmits only in one direction.**

(B) Half-Duplex Channel

- It is a single physical channel in which the **direction may be reversed.**
- Here, **messages flow in two directions** as a half-duplex type, **but never at the same time.** At a single time, the transmission of data is done in only one direction.
- In a **telephone call,** we can observe this type of condition; we can see one party speaks while the other listens and when the other speaks, the first listens. When both speak simultaneously, it will result in a garbled sound that cannot be understood.
- The main problem of half-duplex mode of transmission is that since two channels are used, the bandwidth of the channel is decreased here.

(C) Full-Duplex Channel

- A full-duplex channel is used for **transmitting simultaneous message exchange in both directions.**
- It has **two simplex channels,** one forward channel and other backward (reverse) channel, both linking at the same points.
- The main problem of the full-duplex mode of transmission is that we are using two channels simultaneously, so this **bandwidth** is also **decreased.**

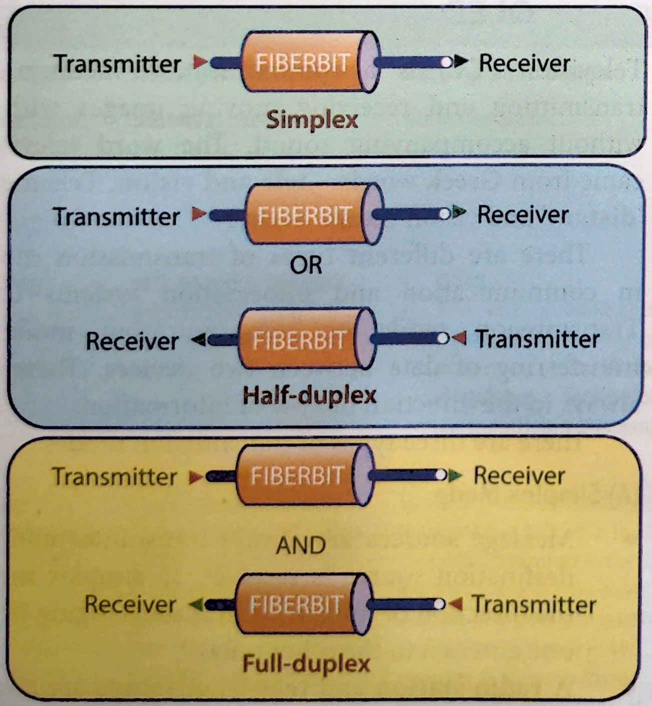


Figure 26.5
Different Types of Transmission Modes

There are different types of TV, depending upon the display device used. A display device is an output device for presentation of information in visual form. When the input information is supplied as an electrical signal, the display is called an electronic display.

There are two main types of display devices: (a) Cathode ray tube and (b) Flat-panel display.

(A) Cathode Ray Tube

The cathode ray tube (CRT) is a vacuum tube containing an electron gun (a source of electrons) and a fluorescent screen, with internal or external means to accelerate and deflect the electron beam, used to create images in the form of light emitted from the fluorescent screen. **Television has primary colours – red, blue and green.**

(B) Flat-Panel Display

There are different technologies used under flat-panel display such as LCD, Plasma, LED, OLED.

I. Liquid Crystal Display (LCD)

- LCD (liquid crystal display) television screens are made up of a thin layer of liquid crystals sandwiched between two glass plates. When an electric current is sent through the crystals, an array of tiny multi-coloured pixels light up to create a picture.
- LCD TV screens are thinner and lighter than plasma screens. They are the most used screens for computers, and are quickly gaining popularity as TV screens.
- LCD TV screens are anywhere from 1/4″ to 4″ thick and 2″ to 65″ wide.
- 'Twisted Nematic' liquid crystal substances are used in LCD television. These operate by twisting between 0 and 90 degrees, thus polarising the light as it passes through it. **4'-Propoxy-[1,1'-Biphenyl]-4carbonitrile (C16 H15 NO)** and **Trans-1-(bromomethyl)4-propylcyclohexane (C10 H19 Br)** liquid crystal materials are used in LCD TV. Another common chemical to

be used in LCD screens is **MBBA**, or **N-(4-Methoxybenzylidene)-p-n-butylaniline**.

COMPARISON WITH CRT AND LCD DISPLAY

- LCD is light weight (typically 1/5 of CRT)
- In LCD, power consumption is lesser (typically ¼ of CRT)
- In LCD, there is no electromagnetic emission
- LCD are large screens (>20 inches) on desktops
- LCD are completely flat screen – no geometrical errors like CRT television
- LCD have crisp pictures – digital and uniform colours
- In LCD, fully digital signal processing is possible
- LCD has low luminance

II. Plasma TV

- They are called 'plasma' displays because the technology utilises small cells having electrically charged ionised gases.
- It is capable of producing deeper blacks, allowing a far superior contrast ratio. Plasma TV screens have a much higher resolution than CRT screens.
- In fact, the picture is so clear that it is almost like watching a scene through a window. Screen sizes range from 42″ to 65″ wide and are 3″ to 4″ thick.

PLASMA vs LCD AND LED FEATURES

- **Picture quality:** Plasma TVs have better viewing angle – how far you can sit to one side of a TV screen before picture quality is affected.
- **Screen life:** Plasma TVs have a screen life of about 30,000 to 60,00 hours, depending on the make and model, while LCD TVs have a screen life of 60,000 hours or more.
- **Plasma is a technology of large-size screen and is heaviest in all television (LCD and LED).** In mobile screen, plasma screen is not possible so we are using LCD and LED screen in mobile phone display.
- **Plasma TV consumes maximum power** in comparison to LCD and LED.

III. LED TVs

- LED is commonly known as **'backlight LCD television'**.
- In this technology, **light-emitting diodes use to backlight** the display device **instead of cathode fluorescent lights used in LCD television.**
- The use of LED backlighting allows for a **thinner panel, lower power consumption, better heat dissipation,** a **brighter display** and **better contrast levels.**

DIFFERENCE BETWEEN LED AND LCD

- LEDs produce images with greater dynamic contrast
- With edge-LED lighting can be extremely slim, some screens less than half an inch (0.92 cm) thick
- LED TVs do not heat-up and so have maximum screen life
- LEDs produce less environmental pollution on disposal
- LEDs are more expensive
- LEDs consume less power than LCD and Plasma
- LEDs have typically 20–30% lower power consumption
- LEDs are more reliable
- LEDs can allow a wider dimming range

IV. OLED (Organic Light-Emitting Diode)

OLED (organic light-emitting diodes) is a flat light-emitting technology, made by **placing a series of organic (carbon based) thin films between two conductors**. OLED is a green technology that is very efficient and does not contain any bad metals.

The basic structure of an OLED is a **cathode (which injects electrons), an emissive layer** and an **anode (which removes electrons)**. More layers are used in modern OLED devices in order to make them more efficient, but the basic functionality remains the same.

Benefits of OLEDs

- OLEDs have low power consumption and can be operated as a light source. OLEDs can produce white light and can provide the bulb of the future – low power (maybe even more efficient than CFL lamps) and thin area designs (and no bad metals).
- The materials are deposited by industrial coating processes, which are cheaper than the techniques required to make conventional LEDs.
- Because OLEDs emit light, they do not require a backlight and so are thinner and more efficient than LCD displays (which do require a white backlight).
- OLEDs have a better picture quality – good colours, quick response rate and a wide viewing angle.
- They are inherently thin.
- They can be made on **flexible plastic substrates,** which will almost certainly lead to full colour flexible displays less than 1-millimetre thick.

- Multiple colours and all colours are possible.

Disadvantages of OLEDS

- Today, it costs more to produce an OLED than it does to produce an LCD – although this should hopefully change in the future, as OLEDs have a potential to be even cheaper than LCDs because of their simple design.
- OLEDs have limited lifetime (like any display, really), that was quite a problem a few years ago but there has been constant progress, and today this is almost a non-issue.
- OLEDs can also be problematic in direct sunlight, because of their emissive nature. But companies are working to make it better.
- Certain materials in OLEDs are incredibly sensitive to moisture, which leads to short life, particularly on plastic substrates. This is the main reason for holding back flexible OLED manufacture.

Quantum LED (QLED)

QLED stands for **quantum light-emitting diode**. It is like a regular LED TV; however, it uses tiny nanoparticles called **quantum dots** to super-charge its brightness and colour. The technology was introduced by Sony in 2013, but shortly after that, Samsung began selling its QLED TVs and established a licencing partnership with other manufacturers.

TABLE 26.7 QLED vs OLED

Parameter	QLED	OLED
Name	Quantum Light-emitting Diode	Organic Light-emitting Diode
Technology	Transmissive	Emissive
Contrast and Black levels	Occurrence of Light Bleed	Perfect darkness
Brightness	Separate backlights	Own light
Colours	Excellent	Fantastic
Refresh rate, response time, and input lag	2 to 8 millisecond - response time	Response time of 0.1 millisecond
Viewing angle	Centre	Up to 84 degrees
Screen Size	Higher range	Lower range
Lifespan	Excellent track record	Moderate
Screen burn-in	Not susceptible	At times, burn-in can occur
Power Consumption	More	Less
Pricing	Comparatively less expensive	More expensive

26.17 QUANTUM COMPUTING

Refer **Infographic – Quantum Computing**.

26.18 QUANTUM SUPREMACY

Refer **Infographic – Quantum Supremacy**.

26.19 QUANTUM BITS

Refer **Infographic – Quantum Bits**.

26.20 QUANTUM KEY DISTRIBUTION (QKD)

Refer **Infographic – Quantum Key Distribution**.

26.21 QUANTUM ENTANGLEMENT

Refer **Infographic – Quantum Entanglement**.

26.22 QUANTUM SATELLITE

Refer **Infographic – Quantum Satellite**.

26.23 QUANTUM TELEPORTATION

Refer **Infographic – Quantum Teleportation**.

26.24 DIFFERENCE BETWEEN CLASSICAL COMPUTER AND QUANTUM COMPUTER

Refer **Infographic – Classical Computers vs Quantum Computers**.

26.25 MICROWAVE OVEN

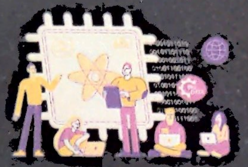
A microwave is much like the electromagnetic waves that zap through the air from TV and radio transmitters. It is an invisible up-and-down pattern of electricity and magnetism that races through the air at the speed of light (300,000 kilometres or 186,000 miles per second). Microwaves are effectively the shortest radio waves and the microwaves that cook food in ovens are just 12 centimetres (roughly 5 inches) long.

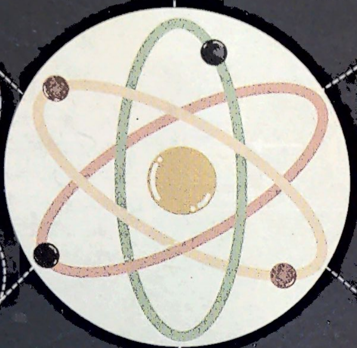
Despite their small size, microwaves carry a huge amount of energy. One drawback of microwaves is that they can **damage living cells and tissues**. This is

QUANTUM COMPUTING

WHAT IS QUANTUM COMPUTING?

Quantum computing is an advanced computing paradigm that utilizes principles from quantum physics to process and manipulate information.





Researchers and companies are actively working on developing and improving quantum hardware, algorithms, and error correction techniques to unlock the full potential of quantum computing.

Instead of classical bits, quantum computers use quantum bits, or qubits, which can represent multiple states simultaneously due to a property called superposition.

Quantum computers have the potential to solve complex problems more efficiently than classical computers.

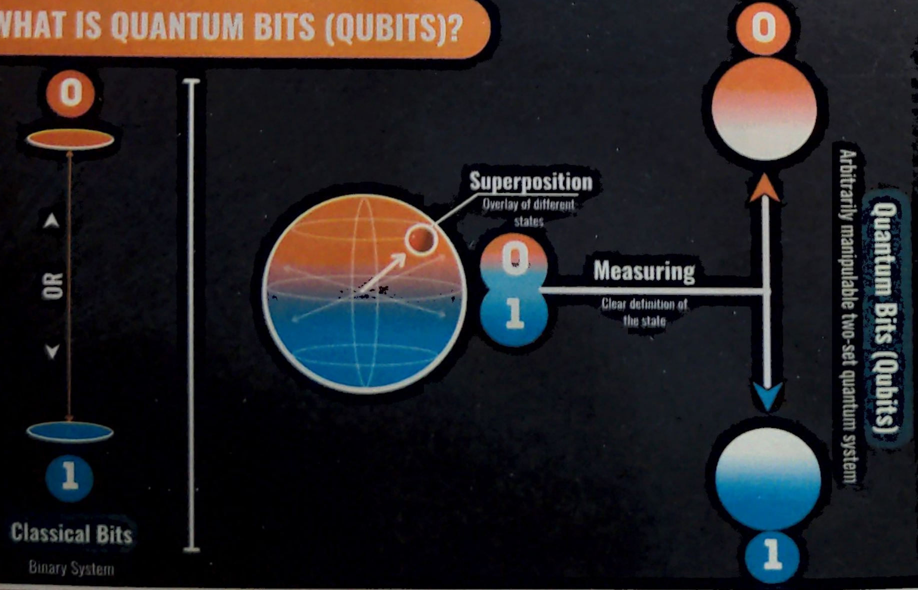
Superposition allows quantum computers to perform parallel computations and explore different solutions simultaneously, potentially leading to exponential speedup in certain computational tasks.

Quantum computing has the potential to revolutionize fields such as cryptography, optimization, simulation, and machine learning.

WHAT IS QUANTUM SUPREMACY?

- Quantum supremacy **refers to the state when a quantum computer can solve a specific problem that is practically infeasible for classical computers to solve within a reasonable amount of time.**
- It signifies **a milestone where quantum computers demonstrate their ability to outperform classical computers** in performing a particular computational task.
- Achieving quantum supremacy serves as an important proof-of-concept and showcases the potential power and capabilities of quantum computing.
- It also highlights the need for continued advancements in quantum hardware, algorithms, and error correction techniques to unlock the full potential of quantum computing in various domains.

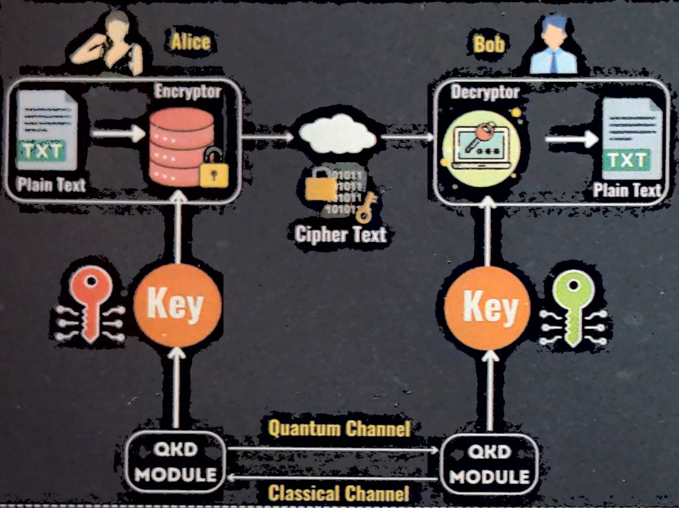
WHAT IS QUANTUM BITS (QUBITS)?


0
OR
1
Classical Bits
Binary System
Superposition
Overlay of different states
0
1
Measuring
Clear definition of the state
0
1
Quantum Bits (Qubits)
Arbitrarily manipulable two-set quantum system

- **Qubit is a two-dimensional quantum-mechanical system (or two-dimensional) system,** one of the simplest quantum systems that reflects the rarity of quantum mechanics.
- In the classical system, the bit will have to be in 0 or 1. However, **quantum mechanics allows qubit to occupy a high degree of coherence for both regions simultaneously,** a basic position in quantum mechanics and quantum computing. This means that **a qubit can be a combination of 0 and 1 at the same time, represented mathematically as 0 and 1.**
- **It is this ability of qubits to be in superposition that gives quantum computers their unique computational power.**
- To create a qubit, an object capable of achieving quantum superposition between two states is required.
- **One type of qubit is an atomic nucleus.**

WHAT IS QUANTUM KEY DISTRBUTION

- Quantum Key Distribution (QKD) is a cryptographic protocol that utilizes the principles of quantum mechanics to securely distribute encryption keys between two parties, typically referred to as Alice and Bob. The goal of QKD is to establish a secret key that can be used for secure communication.
- QKD takes advantage of the fundamental properties of quantum mechanics, such as the uncertainty principle and the no-cloning theorem. It uses individual quantum particles, such as photons, to encode the information of the encryption key.
- The security of QKD is based on the laws of quantum mechanics, making it resistant to certain types of attacks. If any eavesdropping or interception attempts occur during the transmission, they will introduce errors that Alice and Bob can detect.
- QKD provides a means of secure key exchange, which can be used for subsequent encryption of data using classical cryptographic algorithms. It offers a potentially unbreakable method of key distribution, providing a strong foundation for secure communication in various applications, including finance, government, and military sectors.



PROCESS

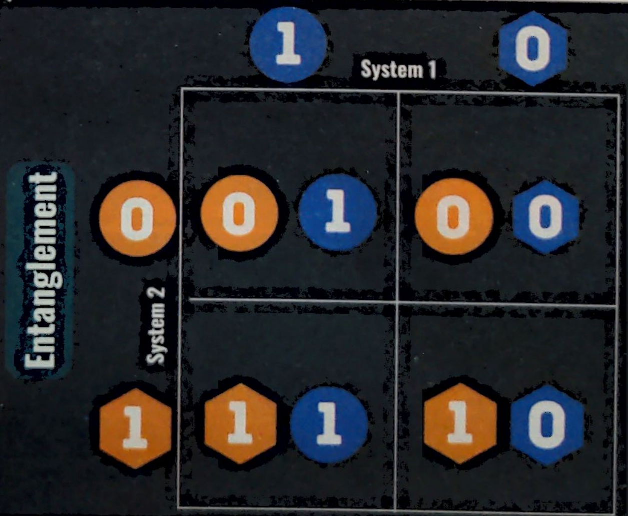
1. **Key Generation:** Alice generates a stream of qubits and sends them to Bob. Each qubit represents a random bit (0 or 1) of the encryption key.
2. **Quantum Transmission:** Alice sends the qubits to Bob through a quantum channel, which can be a fiber-optic cable or free-space transmission.
3. **Measurement and Encoding:** Bob receives the qubits and performs measurements on them using compatible bases. The bases are randomly chosen for each qubit.
4. **Key Exchange:** Alice and Bob publicly communicate the bases they used for each qubit transmission. They discard the qubits for which different bases were used.
5. **Error Correction:** Alice and Bob perform error correction and privacy amplification protocols to eliminate errors and potential information leakage, ensuring a final shared secret key.

WHAT IS QUANTUM ENTANGLEMENT?

- Quantum entanglement is a fundamental phenomenon in quantum physics where two or more particles become deeply interconnected, regardless of the distance between them.
- When particles are entangled, the states of the particles become linked in such a way that the behavior of one particle is instantly correlated with the behavior of the other, even if they are far apart.
- The key characteristic of quantum entanglement is that the entangled particles lose their individual identities and instead form a combined system with interdependent properties. This means that measuring or changing the state of one entangled particle instantaneously affects the state of the other, regardless of the physical distance between them. This instantaneous correlation, which Albert Einstein referred to as "spooky action at a distance," is a unique feature of quantum entanglement.
- In the context of quantum entanglement, the states of particles are not limited to the classical binary states of 0 and 1. Instead, particles in a quantum system can exist in a superposition of states, which means they can be in a combination of 0 and 1 simultaneously. This is one of the key differences between classical and quantum systems.

Entanglement
Observed here
Affected over here

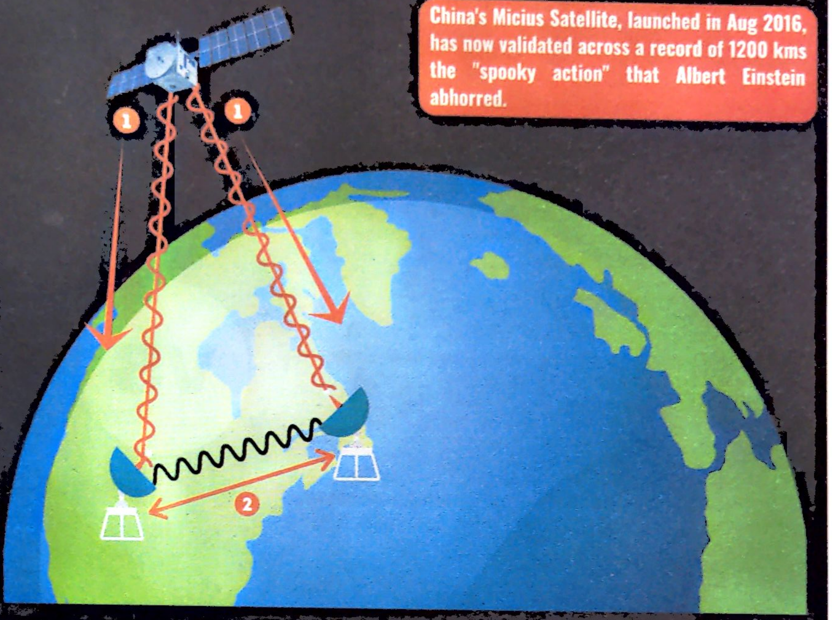
Two qubits can strongly correlate with each other even if they are located light years apart. In the quantum world this entanglement is used to encode problems



WHAT IS QUANTUM SATELLITE?

- A quantum satellite, also known as a quantum communication satellite, is a **specialized satellite designed to enable quantum communication and quantum information processing between ground-based stations.** It leverages the unique properties of quantum mechanics to enable secure communication and other quantum-enabled applications.
- **Purpose:** Quantum satellites are designed to enable quantum communication and quantum information processing between ground-based stations.
- **Entangled Photon Distribution:** Quantum satellites facilitate the distribution of entangled photon pairs between different ground stations.
- **Quantum Communication Protocols:** The entangled photons generated by the satellite are used for various quantum communication protocols, such as quantum key distribution (QKD).
- **Secure Communication:** Quantum satellites enable secure communication by establishing cryptographic keys using the properties of entangled photons.
- **Long-Distance Transmission:** Satellite-based systems allow for long-distance transmission of entangled photons without significant signal loss or interference from atmospheric conditions or fiber limitations.
- **Global Quantum Networks:** Quantum satellites have the potential to facilitate global-scale quantum networks, enabling secure quantum communication on a global scale.
- **Advancements in Technology:** Quantum satellites are an area of active research and development, with ongoing efforts to improve their capabilities and explore new applications in secure communication and quantum information processing.

China's Micius Satellite, launched in Aug 2016, has now validated across a record of 1200 kms the "spooky action" that Albert Einstein abhorred.

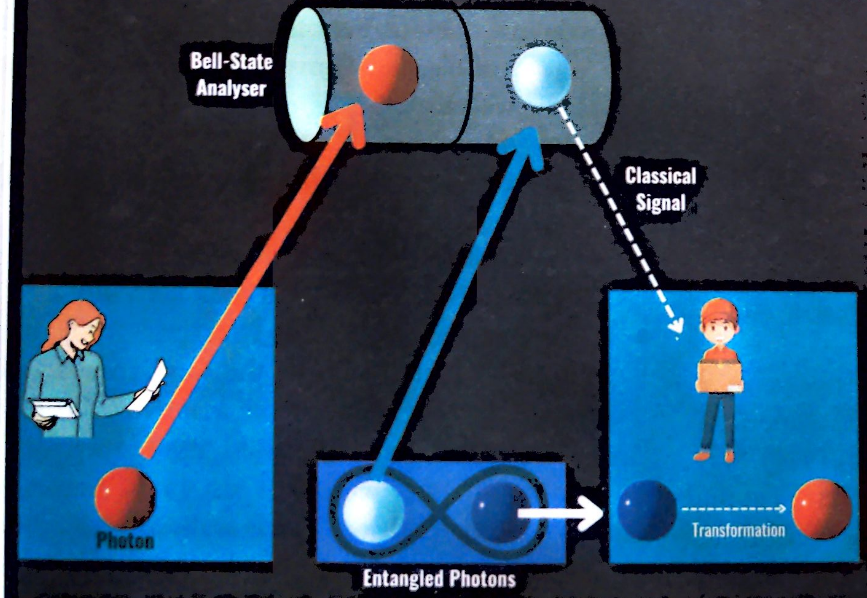


Satellite-to-ground quantum communication and samples of the quantum Internet.

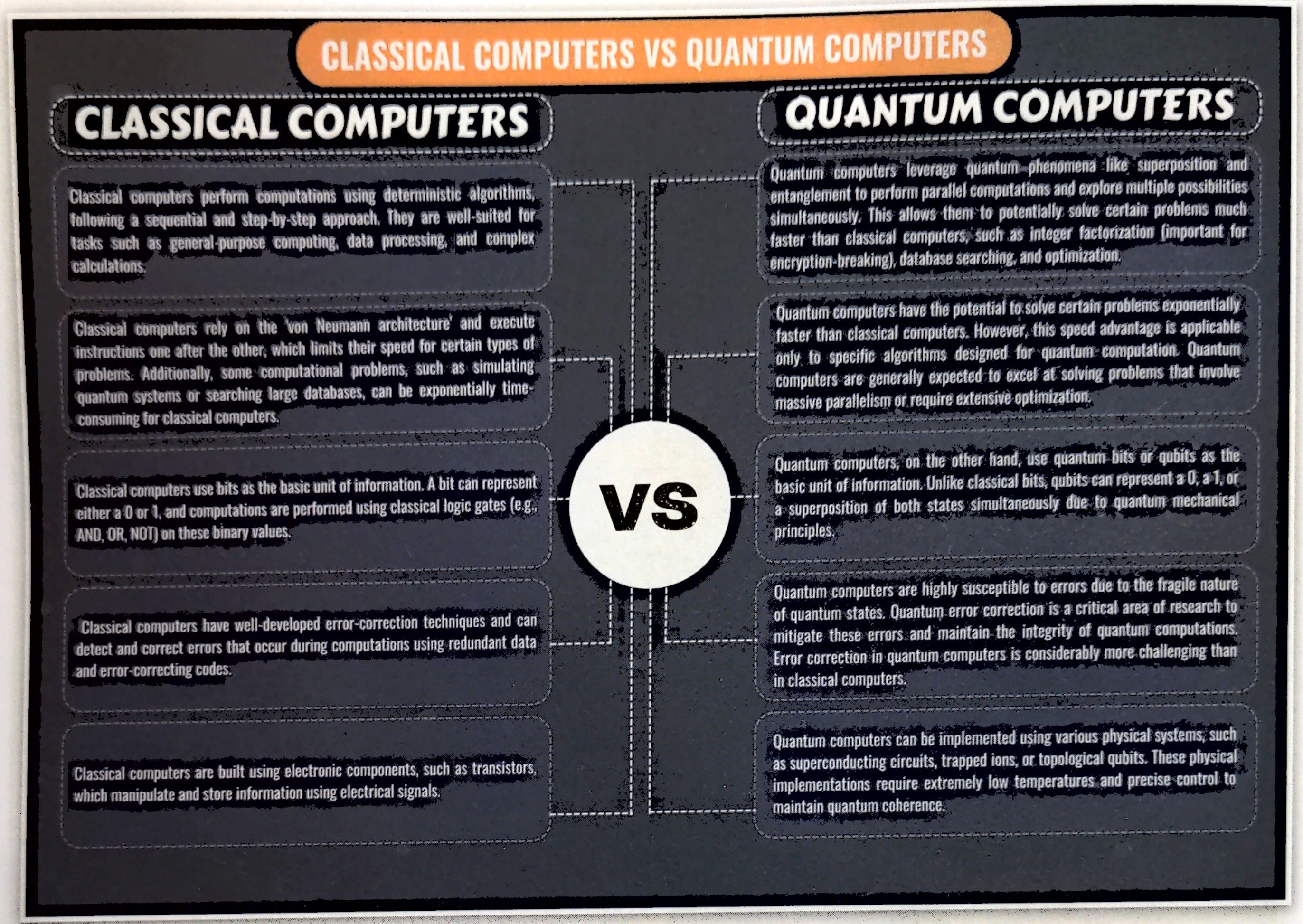
1. **A satellite produces an entangled pair of photons and sends one photon to each station. The probability that each photon arrives at the destination.**
2. **A link between the two ground stations is formed when both photons arrive.**

WHAT IS QUANTUM TELEPORTATION?

- Quantum teleportation is a remarkable concept in quantum physics that involves the **transfer of quantum information from one location to another without physically moving the particle itself.** It allows for the instantaneous transfer of the quantum state of a particle from a sender (Alice) to a receiver (Bob), even if they are separated by a large distance.
- Here's a breakdown of quantum teleportation:
  - a. **Initial Entanglement:** Alice and Bob must first establish an entangled pair of particles, typically referred to as an entangled Bell pair. This entanglement ensures a strong correlation between the particles.
  - b. **Preparing the Quantum State:** Alice wants to teleport an unknown quantum state of a particle (referred to as the "quantum state to be teleported") to Bob. She combines the unknown particle with her entangled particle from the Bell pair.
  - c. **Measurement and Communication:** Alice performs measurements on both her unknown particle and her entangled particle. These measurements provide her with some classical information.
  - d. **Sending Classical Information:** Alice communicates the results of her measurements (classical information) to Bob through a classical communication channel, such as a phone line or the internet. This information contains the instructions for Bob to apply specific operations on his entangled particle.
  - e. **State Reconstruction:** Bob uses the classical information received from Alice to perform the necessary operations on his entangled particle. By doing so, Bob transforms his particle into an approximate replica of the unknown quantum state initially possessed by Alice.



- It is important to note that **quantum teleportation does not involve the actual transportation of particles from one place to another. Instead, it relies on the principles of entanglement and the transfer of classical information to achieve the replication of the quantum state at a different location.**
- Quantum teleportation is a crucial concept in quantum information science and has potential applications in quantum computing, secure communication, and quantum networking. It demonstrates the intriguing and counterintuitive aspects of quantum mechanics, showcasing the power of quantum entanglement and the transfer of quantum information.



CLASSICAL COMPUTERS VS QUANTUM COMPUTERS

CLASSICAL COMPUTERS	QUANTUM COMPUTERS
Classical computers perform computations using deterministic algorithms, following a sequential and step-by-step approach. They are well-suited for tasks such as general-purpose computing, data processing, and complex calculations.	Quantum computers leverage quantum phenomena like superposition and entanglement to perform parallel computations and explore multiple possibilities simultaneously. This allows them to potentially solve certain problems much faster than classical computers, such as integer factorization (important for encryption-breaking), database searching, and optimization.
Classical computers rely on the 'von Neumann architecture' and execute instructions one after the other, which limits their speed for certain types of problems. Additionally, some computational problems, such as simulating quantum systems or searching large databases, can be exponentially time-consuming for classical computers.	Quantum computers have the potential to solve certain problems exponentially faster than classical computers. However, this speed advantage is applicable only to specific algorithms designed for quantum computation. Quantum computers are generally expected to excel at solving problems that involve massive parallelism or require extensive optimization.
Classical computers use bits as the basic unit of information. A bit can represent either a 0 or 1, and computations are performed using classical logic gates (e.g., AND, OR, NOT) on these binary values.	Quantum computers, on the other hand, use quantum bits or qubits as the basic unit of information. Unlike classical bits, qubits can represent a 0, a 1, or a superposition of both states simultaneously due to quantum mechanical principles.
Classical computers have well-developed error-correction techniques and can detect and correct errors that occur during computations using redundant data and error-correcting codes.	Quantum computers are highly susceptible to errors due to the fragile nature of quantum states. Quantum error correction is a critical area of research to mitigate these errors and maintain the integrity of quantum computations. Error correction in quantum computers is considerably more challenging than in classical computers.
Classical computers are built using electronic components, such as transistors, which manipulate and store information using electrical signals.	Quantum computers can be implemented using various physical systems, such as superconducting circuits, trapped ions, or topological qubits. These physical implementations require extremely low temperatures and precise control to maintain quantum coherence.

why microwaves can be harmful to people and why microwave ovens are surrounded by strong metal boxes that do not allow the waves to escape.

In normal operation, microwave ovens are perfectly safe. Even so, microwaves can be very dangerous, so never fool around with a microwave oven. Microwaves are also used in cellphones (mobile phones), where they carry your voice back and forth through the air and radar.

History

Like many great inventions, microwave ovens were an accidental discovery. Back in the 1950s, American electrical engineer Percy Spencer (1894–1970) was carrying out some experiments with a magnetron at the Raytheon Manufacturing Company, where he worked. At that time, the main use for magnetrons was in radar, a way of using radio waves to help airplanes and ships find their way around in poor weather or darkness.

Working mechanism of Microwave Oven

- Inside the strong metal box, there is a microwave generator called a **magnetron**. When you start cooking, the magnetron takes electricity from the power outlet and converts it into high-powered radio waves.
- The magnetron blasts these waves into the food compartment through a channel called a waveguide.
- The food sits on a turntable, spinning slowly around so the microwaves cook it evenly.
- The microwaves bounce back and forth off the reflective metal walls of the food compartment, just like light bounces off a mirror. When the microwaves reach the food itself, they do not simply bounce off. Just as radio waves can pass straight through the walls of your house, microwaves penetrate inside the food. As they travel through it, they make the molecules inside it vibrate more quickly. Vibrating molecules have heat, so, the faster the molecules vibrate, the hotter the food becomes. Thus, the microwaves pass their energy onto the molecules in the food, rapidly heating it up.

Health Hazards

Microwave radiation can heat body tissue in the same way as it heats food. Its higher exposure can cause a painful burn. Its higher level on eye lens causes cataracts. Microwave ovens always used low level of microwaves, within the region of non-ionising radiation. The effects of long-term exposure of microwaves on human body are still uncertain. It is best to stay away (an arm's length) in reducing its exposure.

26.26 BLACK BOX IN AN AIRPLANE

Any commercial aeroplane or corporate jet is required to be equipped with a **cockpit voice recorder** and a **flight data recorder**. It is these two items of separate equipment which we commonly refer to as a '**black box**.' While they do nothing to help the plane when it is in the air, both these pieces of equipment are vitally important should the plane crash, as they help crash investigators find out what happened just before the crash.

To help locate the cockpit voice recorder and a flight data recorder in the aftermath of a plane crash that occurs at sea, each recorder has a device fitted to it known as an **underwater locator beacon (ULB)**. The device is activated as soon as the recorder comes into contact with water and it can transmit from a depth as deep as 14,000 feet. Also, to help investigators find them; a black box is not actually black at all, but bright orange.

26.27 ACCELEROMETER

Refer Infographic – Accelerometer.

26.28 INDIAN STANDARD: ELECTRONIC ITEMS, FOOD AND AGRICULTURE RELATED

26.28.1 Bureau of Indian Standard (BIS)

The Bureau of Indian Standards (BIS) is the national standards body of India under the **Ministry of Consumer Affairs, Food and Public Distribution**, Government of India. It was established by the **Bureau of Indian Standards Act, 1986**, and came to effect from 23 December 1986. The BIS is engaged in the activities of standardisation, conformity assessment and quality assurance of goods, articles, processes, systems and services.

The BIS certification scheme is basically **voluntary** in nature. However, for a number of products compliance to Indian Standards is made compulsory by the Central Government under various considerations viz. **public interest, protection of human, animal or plant health, safety of environment, prevention of unfair trade practices and national security**.

The BIS is the National Standards Body of India (NSB). It has **three major activities**:

1. **Standard formulation**
2. **Certification activities:** This is the primary activity of BIS with a majority of its workforce engaged in certification activities. It includes factory visits, examining product at the workplace, checking factory laboratories for availability of proper testing equipment, handling new licence applications, renewing/rejecting old ones, enforcement activities etc.
3. **Laboratories:** This activity includes receiving samples sent by certification officer, applying proper tests, preparing reports and also (kind of) giving a verdict on whether the product meets the corresponding standard.

Objectives

- Harmonious development of standardisation, marking and quality certification.
- To provide new thrust to standardisation and quality control.
- To evolve a national strategy for according recognition to standards and integrating them with growth and development of production and exports.

26.28.2 Indian Standard Institutions (ISI)

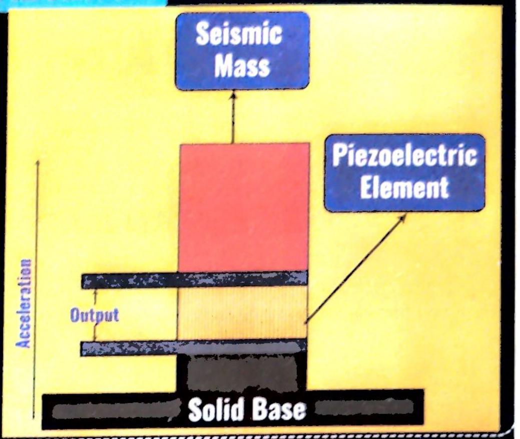
The ISI mark is a standards-compliance mark for **industrial products in India** since 1950. The mark certifies that a product conforms to an Indian standard (IS) developed by the Bureau of Indian Standards (BIS), the national standards body of India.

On 1 January 1978, it was renamed to the Bureau of the Indian Standards. The ISI mark is mandatory for a certain products to be sold in India, such as many of the electrical appliances like switches, electric motors, wiring cables, heaters, kitchen appliances etc., and other products like Portland Cement, LPG valves, LPG cylinders, automotive tyres etc. In the case of most

ACCELEROMETER

WHAT IS AN ACCELEROMETER?

- An accelerometer is a **sensor or device that measures acceleration forces acting on an object**. It detects and quantifies changes in velocity or acceleration in a specific direction. Accelerometers are widely used in various industries, including automotive, aerospace, robotics, consumer electronics, and healthcare, to measure and monitor motion, vibrations, and orientation.
- Accelerometers work based on different principles, depending on the type of accelerometer.
- Two common types are
    - **Piezoelectric accelerometers:** Piezoelectric accelerometers utilize piezoelectric crystals or materials that generate electrical signals when subjected to applied acceleration. These crystals convert the mechanical strain caused by acceleration into an electrical charge, which can be measured and interpreted.
    - **Microelectromechanical systems (MEMS) accelerometers:** MEMS accelerometers, on the other hand, rely on microfabrication techniques to create tiny structures, such as capacitive plates or piezoresistors, on a semiconductor chip. Changes in acceleration cause these structures to deform, altering the electrical properties and generating signals that can be processed and analyzed.
- Units of acceleration, such as meters per second squared (m/s^2) or gravitational forces (g), are commonly used to express the measurements obtained from accelerometers.
- To ensure accurate measurements, accelerometers often require calibration. This process involves comparing the output of the accelerometer to known reference values and making adjustments if necessary. Factors affecting accelerometer accuracy include noise, sensitivity, and temperature.



WORKING PRINCIPLE OF ACCELEROMETER?

- **Accelerometers are devices that measure how quickly something is moving or changing speed.**
- They work by using special materials that produce electricity when they are squeezed or pushed.
- These materials are built into the accelerometer, and when they experience acceleration or movement, they create an electrical signal.
- This signal is then measured and turned into a number that represents how fast the acceleration or movement is happening.
- This information can be used to detect motion, monitor vibrations, measure tilt, or determine the orientation of an object.
- Different types of accelerometers may have slightly different ways of working, but they all involve measuring changes in acceleration or velocity.

CALIBRATION AND ACCURACY OF ACCELEROMETERS

- Calibration and accuracy are crucial aspects of accelerometers to ensure reliable and precise measurements.
- **Calibration:** Calibration is the **process of adjusting an accelerometer to ensure its measurements align with known reference values.** It involves comparing the output of the accelerometer to a known standard and making necessary adjustments to minimize any measurement errors. During calibration, factors such as sensitivity, zero offset, linearity, and cross-axis sensitivity are evaluated and adjusted as needed. Calibration can be performed using calibration equipment or by referencing certified standards.
- **Accuracy:** Accuracy refers to **how closely the accelerometer's measurements correspond to the true or actual values.** It is influenced by various factors, including sensor design, manufacturing tolerances, calibration quality, and environmental conditions. The accuracy of an accelerometer is typically expressed as a percentage of the full-scale range or as an absolute value in terms of measurement error.
- FACTORS AFFECTING ACCURACY:
    - **Linearity:** The linearity of an accelerometer determines how accurately it measures acceleration across the entire range. Non-linearities can introduce errors in the readings.
    - **Cross-Axis Sensitivity:** Cross-axis sensitivity refers to the accelerometer's sensitivity to acceleration in directions perpendicular to the primary axis of measurement. Accurate measurements require minimizing cross-axis sensitivity to avoid interference from unintended acceleration components.
    - **Temperature Effects:** Accelerometers can exhibit variations in performance with changes in temperature. Thermal effects can impact the sensor's sensitivity and introduce errors if not properly compensated.
    - **Noise and Drift:** Noise refers to random variations in the accelerometer output, while drift represents systematic changes over time. Minimizing noise and drift is important to improve measurement accuracy and stability.
    - **Signal Conditioning and Electronics:** The quality and precision of the signal conditioning circuitry and electronics play a role in maintaining accuracy. Amplification, filtering, and analog-to-digital conversion should be optimized to minimize signal distortions.

APPLICATIONS OF ACCELEROMETERS

AUTOMOTIVE INDUSTRY

- **Vehicle Stability Control:** Accelerometers are used to measure vehicle acceleration and detect sudden changes in motion, enabling systems like electronic stability control and traction control.
- **Airbag Deployment:** Accelerometers help detect rapid deceleration during a collision and trigger airbag deployment for occupant safety.
- **Rollover Detection:** Accelerometers are utilized to sense the tipping or rolling motion of vehicles and activate safety measures accordingly.

CONSUMER ELECTRONICS

- **Screen Orientation:** Accelerometers enable automatic screen rotation in smartphones, tablets, and other devices, adjusting the display based on the device's orientation.
- **Gesture Recognition:** Accelerometers are used to detect specific movements or gestures, enabling interactive features like shake-to-shuffle or tap-to-wake in smartphones.
- **Gaming and Virtual Reality (VR):** Accelerometers play a role in motion-based gaming and VR systems, tracking user movements for immersive experiences.

AEROSPACE AND ROBOTICS

- **Navigation and Orientation:** Accelerometers are essential in inertial navigation systems for aircraft, spacecraft, and autonomous vehicles, providing accurate motion and orientation data.
- **Motion Detection and Stabilization:** In robotics, accelerometers are used for motion detection, gesture recognition, and stabilization of robotic platforms.

SPORTS AND HEALTHCARE

- **Fitness Tracking:** Accelerometers are used in fitness trackers and activity monitors to measure steps, distance traveled, and calories burned.
- **Biomechanical Analysis:** In sports science and rehabilitation, accelerometers help analyze motion patterns, gait analysis, and evaluate body movements during exercises.
- **Prosthetics:** Accelerometers can be used in prosthetic devices to sense movement and adjust the prosthetic limb accordingly.

INDUSTRIAL AND STRUCTURAL MONITORING

- **Vibration Analysis:** Accelerometers are used to monitor vibrations in machinery and equipment, helping detect faults, imbalance, or misalignment.
- **Structural Health Monitoring:** Accelerometers play a role in monitoring the structural integrity of buildings, bridges, and other infrastructure by detecting vibrations, impacts, or structural changes.

other products, ISI marks are optional. Counterfeiting ISI marks is a punishable offence by the law, but enforcement is uncommon.

26.28.3 ECO-Mark Scheme

ECO Mark Scheme was instituted by the Government of India for labelling of environment-friendly products. The scheme is being administered by the Bureau of Indian Standards.

The scheme first saw its application in 1991. It is voluntary in nature and helps in identifying eco-friendly products in the market. The eco-mark scheme falls under the ambit of Ministry of Environment, Forest and Climate Change.

The scheme covers various product categories like soaps and detergents, paints, food items, lubricating oils, packing/packaging materials, architectural paints and powder coatings, batteries, electrical and electronic goods, food additives, wood substitutes, cosmetics, aerosols and propellants, plastic products, textiles, fire-extinguisher, leather and coir and coir products.

The presence of ECO logo along with ISI mark on a product indicates that the product meets certain environmental criteria along with the quality requirements as specified in the relevant Indian Standard.

For implementation of the scheme, BIS is responsible for the following functions:

- Renewal, suspension and cancellation of the licence.
- Undertaking inspections and taking samples for analysis of any material or substance in relation to which the ECO mark has been used.

To operate the scheme, BIS has included additional requirements for ECO mark in the concerned Indian Standards. The terms and conditions governing operation of the licence shall be as per the Bureau of Indian Standards Act, Rules and the Regulations.

26.28.4 AGMARK

AGMARK is a certification mark for agricultural produce, assuring that they conform to a grade standard notified by Directorate of Marketing and Inspection (DMI), Department of Agriculture, Cooperation and Farmers Welfare, **Ministry of Agriculture and Farmers Welfare** under Agricultural Produce (Grading Marking) Act, 1937.

These standards differentiate between quality and 2–3 grades are prescribed for each commodity. Till date, grade standards for 222 agricultural commodities have been notified. These include **fruits, vegetables, cereals, pulses, oilseeds, vegetable oils, ghee, spices, honey, creamery butter, wheat, atta, besan** etc.

While framing the standards, the existing standards in The Food Safety and Standards Act, 2006, **Codex Alimentarius Commission,** International Organization for Standardization, etc. are considered.

CODEX ALIMENTARIUS COMMISSION (CAC)

The Codex Alimentarius Commission or CAC is the body responsible for all matters regarding the implementation of the Joint FAO/WHO Food Standards Programme.

Membership of the Commission is open to all Member Nations and Associate Members of FAO and WHO which are interested in international food standards.

The Commission meets in regular session once a year alternating between Geneva and Rome.

The programme of work of the Commission is funded through the regular budgets of WHO and FAO with all work subject to approval of the two governing bodies of the parent organisations.

26.28.5 Food Safety and Standards Authority of India (FSSAI)

Food Safety and Standards Authority of India (FSSAI) is an **autonomous body** established under **the Ministry of Health and Family Welfare,** Government of India.

It has been established under the Food Safety and Standards Act, 2006 which is a consolidating statute related to food safety and regulation in India.

FSSAI is responsible for **protecting and promoting public health** through the regulation and supervision of food safety.

The FSSAI has its headquarters at **New Delhi**. The authority also has **6 regional offices** located in Delhi, Guwahati, Mumbai, Kolkata, Cochin and Chennai. A total of **14 referral laboratories** notified by FSSAI, 72 State/UT laboratories located throughout India and 112 laboratories are National Accreditation Board for Testing and Calibration Laboratories (NABL) accredited private laboratories notified by FSSAI.

26.29 FOOD AND HEALTH RELATED ISSUES

26.29.1 MSG Maggie Issues

Maggi is an international brand of seasonings, instant noodles and soups that was established in Switzerland. Nèstle acquired the brand in 1947.

Maggi noodles are highly popular in both India and Malaysia. Nestle has 39% market share in Malaysia, where Maggi is synonymous with instant noodles, and 90% market share in India prior to a **nationwide ban by the Food Safety and Standards Authority of India**. The ban reduced the market share to 53% in India. In June 2015, quality tests conducted in India found high amounts of lead in Maggi Noodles.

Food Safety Regulators at Barabanki, Uttar Pradesh, in May 2015, reported that samples of Maggi Noodles had **unexpectedly high levels of monosodium glutamate**, which is **around 17 times the permissible limit of lead**. This report led to multiple market withdrawals and investigations in India and beyond.

The Supreme Court of India has lifted a stay on criminal proceedings against Nestle over the alleged presence of lead and MSG or monosodium glutamate in popular noodles.

What's the Issue?

- The apex court had allowed the case against Nestle to reopen after the Swiss food giant had admitted the presence of toxic ingredients in its noodles during a court hearing.
- Nestle's lawyers have admitted that toxic elements like lead and MSG are found in its sample tests conducted by **CFTRI (Central Food Technological Research Institute), Mysuru.** However, the company has argued that the lead was within the permissible limit.

Effects of Lead and MSG on Health

(A) Lead

- According to the **World Health Organization (WHO),** lead is a cumulative toxicant that affects multiple body systems, including your liver and kidneys in particular.
- It is especially **harmful to infant and pregnant women** as it can cause damage to the **central nervous system in children.**
- Since lead is a heavy metal it can get stored in the teeth and bones, where it accumulates over time. In pregnant women, prolonged exposure to lead can result in **miscarriage, prematurity, low birth weight** etc.

(B) Monosodium Glutamate

- MSG, short form for monosodium glutamate, is an amino acid found in your body and most foods. It is a flavour enhancer commonly added to Chinese food, canned vegetables, soups and processed meats.
- When consumed in excess, it can cause several health issues, including a headache, nausea, sweating, weakness, chest pain, tingling or burning in the face as well as neck and other areas. It is claimed that MSG can cause asthma and even brain damage.
- MSG may cause adverse symptoms in some people, including a condition called Chinese restaurant syndrome or MSG symptom complex. However, there is no definitive evidence that MSG is solely responsible for causing these symptoms.

NATIONAL CONSUMER DISPUTES REDRESSAL COMMISSION (NCDRC)

- The National Consumer Disputes Redressal Commission (NCDRC), India is a quasi-judicial commission in India which was set up in 1988 under the Consumer Protection Act of 1986.
- The commission is headed by a sitting or retired judge of the Supreme Court of India.

Statutory Provisions

- Section 21 of Consumer Protection Act, 1986, provides that the National Consumer shall have jurisdiction to entertain a complaint valued more than one crore and also have Appellate and Revisional jurisdiction from the orders of State Commissions or the District for as the case may be.
- Section 23 of Consumer Protection Act, 1986, provides that any person aggrieved by an order of NCDRC may prefer an Appeal against such order to Supreme Court of India within a period of 30 days.

26.29.2 Bisphenol A (BPA)

Bisphenol A is used in the production of **polycarbonate plastics and epoxy resins.**

Polycarbonate plastics have many applications, some food and drink packaging; for example, water and in front bottles, compact discs, impact safety equipment and medical devices etc. **Epoxy resins** are used as lacquers to coat metal products such as food cans, bottles tops and water supply pipes.

Bisphenol A is found in **hard plastic bottle**. BPA exposure leads to wide variety of health issues, such as **obesity and diabetes. Vitamin D deficiency, cancer, insomnia, arthritis, heart diseases** and **disturbances of hormones** in human body are other problems in human body.

Exposure of BPA in Human Body

The main source of exposure to BPA for most people is through diet, while air, dust and water are other possible sources of exposure. BPA in food and beverages accounts for the majority of daily human exposure.

Bisphenol A can leach into food from the protective internal epoxy resin coatings of canned foods and from consumer products such as polycarbonates, table ware, food-storage containers and water bottles. BPA can also be **found in breast milk**.

Prevent Exposures to BPA

- Do not put polycarbonate plastic food containers in microwaves. Polycarbonate is strong and durable but over time, it may break down from overuse at high temperatures.
- Reduced use of canned food.
- Use bottles that are BPA-free.
- It is better to opt for glass, porcelain or stainless steel containers, particularly for hot food or liquids.
- Plastic containers have recycle codes on the bottom. Some, but not all, plastics that are marked with recycle codes 3 or 7 may be made with BPA.

26.29.3 Polished Rice

The removal of outer bran, husk and germ layer of the rice grain is through the process known as **milling**; after that, rice grain goes through the process of **polishing**, which gives a shiny, whitish appearance to the seeds.

These processes **remove the vital nutrients** from the grain, which is very essential for health. Bran contains many important nutrients, **approximately 80% of the minerals, fibre and essential oils** come from the grains.

Many studies conclude that the fibres prevent many diseases such as **gastrointestinal diseases and heart disease**. Rice bran oil **decreases serum cholesterol**, which is the potent factor in heart diseases. The germ is loaded with **vitamins, minerals, unsaturated fats** etc.

26.29.4 Antioxidants

It is a substance that **inhibits/delays the oxidation process** of other molecules. Oxidation is a chemical process in which oxygen is pooled with other molecules and **produces free radicals that can damage the cells**.

Antioxidants, present naturally in our body and also added to food as a supplement, provide various benefits, and avoid diseases. Some common antioxidants include enzymes and other substances like some Vitamins, β carotene etc. Most common vitamins used as antioxidants are A, C and E. Vitamins D, K and folic acid also increase antioxidant property.

Benefits of Antioxidants

- **Repairs damaged cells**: Many plants and animals produce and store large amounts of anti-oxidants. It helps in reducing the cell damage process and also has the ability to repair damaged cells.
- **Preventing cancer:** National Cancer Institute performed many experiments on animals and observed 'antioxidants help in preventing free radicals' damage that is related to cancer.
- Antioxidants help in **reducing the process of ageing** and may even **lead to longevity**.

26.29.5 Preservatives (Preserve to Reserve)

Preservatives help in maintaining the nutritional viability and extension of duration of food from getting spoiled through the action of microorganisms, specifically bacteria, moulds and yeasts.

Freezing, boiling, smoking, salting, pasteurising, dehydrating and pickling are some traditional natural ways of preserving food. 'Natural food preservatives' like salt, sugar alcohol, vinegar are the preservatives for making pickles, jams and juices. Coffee and soup powder dehydrated and freeze in dry form for preservation. Citrus acid and ascorbic acid work on enzymes and disrupt metabolism and help in preservation.

'Chemical preservatives' are most effective for longer shelf-life. Some examples are benzoates (sodium benzoate, benzoic acid), nitrates (sodium nitrite), sulphites (sulphur dioxide), sorbates (sodium sorbate, potassium sorbate), vitamin C, BHA (butylated hydroxyanisole) and bacterial growth inhibitors like sodium nitrite, sulphur dioxides and benzoic acid. Ethanol is also a chemical preservative in food and wine.

There are **three types of artificial preservatives** of food:

- **Antimicrobial agents** (benzoates, sodium benzoate, sorbates, nitrites)
- **Antioxidants** (sulphites, vitamin E, vitamin C and butylated hydroxytoluene (BHT))
- **Chelating agent** (disodium ethylene diamine tetra acetic acid, polyphosphates and citric acid)

Natural Preservatives include rosemary (Gulmehandi – *Rosmarinus officinalis*) and oregano (ajwain leaves etc.) extract, hops, salt, sugar, vinegar, alcohol, diatomaceous earth and castor oil. Hops are **the flowers (also called seed cones or strobiles) of the hop plant *Humulus lupulus***, a member of the Cannabaceae family of flowering plants. Diatomaceous earth is also called 'Kieselguhr'. Diatomaceous earth is a common alternate name, but the term is more appropriate for unconsolidated or less lithified rock of the same origin.

Disease/Problems	Causes
Asthma	• Sodas contain sodium benzoate, which is used as a preservative to control microbial growth. • Sodium preservatives get mixed with the diet and reduce the content of potassium in our body. • This increases the chances of Asthma, and eczema. • Survey facts: Every day, 370 people die of asthma resulting from these beverage products.
Dissolves Tooth Enamel	• Soft drinks contain high-reactive solvents, which when mixed with saliva, or stomach's digestive acids become acidic in nature. • This starts effecting immediately, in the next second of consumption. • Due to such fast and strong action, our mouth and teeth get affected. • It is observed that each sip of beverage drink damages the enamel of teeth by 2 per cent. • The skin in the mouth and oesophagus is as sensitive as that of a newly born baby. • Soda preservatives develop rashes on this skin. • These rashes make it more difficult, even to have regular diet. • Survey facts: The annual estimation cost for people getting treated for dental problems as a result of these beverage products is ₹450 crore.
Heart Diseases	• The beverage drinks contain fructose corn syrup, which has been associated with an increased risk of metabolic syndrome. • This condition elevates risk of both Diabetes and Heart Diseases. • Survey facts: 1 out of 40 deaths every day are caused by heart strokes, as a result of using beverage products.
Sugar Overloading	• This phenomenon is observed after few minutes of consumption of these beverage drinks. After around 20 minutes of consumption of beverage drink, blood sugar spikes up, causing an Insulin Burst. • At this point, liver acts by converting every sugar molecule into fat. • After 40 minutes, caffeine absorption will be complete. • This dilates pupils, increases blood pressure, which results in liver dumping more sugar into bloodstream. • This blocks the adenosine receptors in brain that prevent drowsiness. • 45 minutes later, the dopamine production is increased, which stimulates the pleasure centres of the brain. • Generally, this effect is observed in Heroin consumers. • Survey facts: Approximately 1 in every 10 rupees spent on medication is for diabetes.
Kidney Issues	• Some of the beverage drinks contain phosphoric acids. • These phosphoric acids effectively disturb the digestive system and supportive organs. • The digestive system is linked to kidneys. • Phosphoric acid increases the chances of formation of stones in kidneys and other renal problems. • Survey facts: Men who are obese should stop consuming these beverage products. They have more increased chances of getting the stones in kidneys, than a general beverage consumer.
Reproductive issues	• The soda cans are coated with resin for great look and shine on it. • This resin contains BPA (Bisphenol-A); this is the same cancer-causing chemical found in plastic baby bottles, water bottles and tinned food cans. • This weakens the endocrine system, potentially causing premature puberty and reproductive abnormalities. • Survey facts: 9 out of the 10 produced soft drinks impact on health, which can be most dangerous.

Disease/Problems	Causes
Osteoporosis	• It is observed that calcium is urinated along with phosphoric acids, by the consumption of these beverage juices and sodas. • This leads to Osteoporosis, which is the weakening or depriving of bones. • Then deficiency of calcium is observed, which is one of the important minerals of the body. • Survey facts: 1 in 2 cases of orthopaedic surgeon would be of weak bones and stuff.
Obesity	• Its risky to consume overloads of soda. • Researchers calculate that each can of soda consumed increases the chance of obesity by 1.6 times. • So it is not advised to consume soda regularly. • Survey facts: 2 in 5 children of the younger generation are found to be suffering from obesity. The increased chances of above problems are mostly found in people who consume beverage drinks and sodas on a regular basis. Most of the medical practitioners and dieticians prefer fresh fruit juices like kiwi fruit shakes. So do justice to yourself by cutting down the consumption of these beverage products.

26.29.6 Aerated Drinks / Soft Drinks

A soft drink contains **carbonated water, a sweetener and a natural or artificial flavouring**.

The sweetener may be sugar, high-fructose corn syrup, aspartame (neotame, acesulfame and sucralose are sweeteners being used sometimes), fruit juice, sugar substitutes (in the case of diet drinks), or some combination of these.

Acids like phosphoric acid in colas and citric acid in citrus-flavoured drinks are added to soft drinks for extra bite and feel. Carbonated water (carbon dioxide dissolved in water under pressure) is also mildly acidic (chemically carbonic acid, H_2CO_3).

Caffeine is added as a stimulant, but it has a bitter taste that is a component in many soft drinks. Orange soda often contains **glyceryl abietate** and **brominated vegetable oil**. These help keep fatty flavours suspended in the liquid (density balancers and emulsifiers). Gums and modified food starches are also used for this purpose.

Sodium benzoate is used as a **broad spectrum antimicrobial**, inhibiting bacteria, moulds and yeasts. The high acid content of the soft drink is necessary for the preservative action.

Sodium citrate buffers the acids, so the pH stays low (acidic). It also emulsifies any fats or fat-soluble compounds in the flavourings, keeping them in solution.

Potassium sorbate is added to inhibit yeasts and fungi.

Ascorbic acid (vitamin C) is used as an antioxidant. In colas, the colour comes from caramel colouring (burnt sugar).

Red 40 and **other colours** are used in fruit-flavoured drinks such as orange soda.

26.29.7 Pesticides in Cold Drinks or Soft Drinks

Large multi-national corporations follow dual standards especially when it comes to developing countries. Soft drinks industry is a classic case of this as the Centre for Science and Environment (CSE) discovered way back in 2003 and Indian Medical Association (IMA) has also proven the same in past.

Centre for Science and Environment (CSE): It is a non-governmental organisation based in New Delhi. It has set up the Pollution Monitoring Laboratory (PML) to monitor environmental pollution.

Aims: To undertake scientific studies to generate public awareness about food, water and air contamination.

- Equipped with state-of-the-art equipment for monitoring and analysis of air, water and food contamination, including high performance liquid chromatograph (HPLC), gas chromatograph (GC) with ECD, NPD, FID and other detectors, UV-VIS spectrophotometer, mercury analyser, respirable dust sampler etc.
- Way back in 2003, CSE found high levels of toxic pesticides and insecticides, high enough to cause cancer, damage to the nervous and reproductive systems, birth defects and severe disruption of the immune system.
- According to CSE 2003 reports, market leaders Coca-Cola and Pepsi had almost similar concentrations of pesticide residues, when they were compared with the soft drink brands sold in the United States, to see if they contained pesticides, they did not. This shows how the companies were following dual standards.

- Shocked by this report, government constituted a **Joint Parliamentary Committee (JPC)** to find out whether the findings of the CSE regarding pesticide residues in soft drinks are correct or not and to suggest criteria for evolving suitable safety standards for soft drinks, fruit juice and other beverages where water is the main constituent.
- The JPC report vindicated CSEs findings and said it is prudent to seek complete freedom from pesticide residues in sweetened aerated water.
- In August 2006, CSE undertook a nationwide study of nearly a dozen soft drink brands and found pesticide residues in all samples. CSE carried out the tests on 57 samples of 11 soft drink brands. The samples were collected from 25 separate manufacturing units of PepsiCo and Coca-Cola spreading across 12 states. As per the study, 3–5 different pesticides were available in all the samples on an average. The amount of pesticides found were 24 times more than the Bureau of Indian Standards (BIS) norms.

Pesticides found as per CSE 2006 study

- **Lindane:** 140 times higher than BIS standards
- **Heptachlor:** 4 times higher than BIS standards. Heptachlor is actually banned in India
- **Chlorpyrifos and neurotoxin:** 200 times more than the BIS standard (in some samples). The average amount of pesticide residue in Pepsi and Coca-Cola, was 30 times and 27 times higher than BIS standards, respectively. Pesticide range higher than 2.1% is very harmful to the liver and can cause cancer.

Health impacts of pesticides Lindane

1. A confirmed carcinogen, it increases the risk of liver cancer
2. Too much consumption can damage kidney, immune and neural system
3. Affects reproductive performance in males
4. Lowers down sexual receptivity in females

Chlorpyrifos

1. Affects brain cell development
2. Over chlorpyrifos consumption may lead to growth retardation, behavioural abnormalities and muscle weakness
3. Can cause immunological changes

Heptachlor (Banned in India)

1. Can cause tremors and convulsions
2. Respiratory failure
3. Liver damage

In 2003, the average level of pesticide residue in soft drinks were 34 times above the BIS standard, whereas now it is in range of 42–52 times above the BIS standard.

The companies did not implement the directions given by the Joint Parliamentary Committee for ensuring safety standards because of opposition.

26.22.8 Fats: Types, Trans Fat and Omega 3

Fats are nutrients in food that the body uses to build nerve tissue (including the brain and nerves) and hormones. Human body also uses fat as fuel. Unused fats are stored by the body in fat cells. Fats are required to human body for absorption of some vitamins (vitamins A, D, E and K are fat-soluble, meaning they can only be absorbed if there is fat in a person's diet).

There are different levels of importance to human beings:

- Fats are the building blocks of hormones.
- Fats are necessary for insulating all nervous system tissues in the body.
- Fats help people feel full, so they are less likely to eat as much.
- Fat is a great source of energy but has twice the amount of calories, compared with the same amount of carbohydrates or protein.
- For example, 1 gram of fat provides 9 calories, whereas 1 gram of both carbohydrates and protein provide 4 grams each.
- Desserts and snacks (including potato chips, chocolate, cakes, doughnuts, pastries and cookies) are a significant source of fat.
- Kids also get fat from whole-milk products and high-fat meats, such as bacon, hot dogs and non-lean red meat.

Types of fats: There are two types of fats on the basis of chemical compounds and its structure.

1. **Unsaturated fats:** Found in plant foods and fish, these fats are seen as neutral or even beneficial to heart health. The types of unsaturated fats are:
   - ◆ **Monounsaturated**, found in avocados and olives, peanuts and canola oils.

- **Polyunsaturated**, found in most vegetable oils. **Omega-3 fatty acids are a type of polyunsaturated fat found in oily fish like Tuna and Salmon.**

2. **Saturated fats:** Saturated fats are found in meat and other animal products, such as butter, shortening, lard, cheese and milk (except skim or non-fat). Saturated fats are also found in palm and coconut oils, which are often used in commercial baked goods. Eating too much saturated fat can raise blood cholesterol levels and increases the risk of heart disease.

1. The Fat Family Tree

The family of fat is highly complex, so to make it less confusing, picture it as a family tree.

At the top, there are two different families of fat – **saturated fat** and **unsaturated fat.**

Saturated fat like butter is packed with hydrogen atoms, making it solid at room temperature. Unsaturated fat (like olive oil) contains fewer hydrogen atoms, so it is liquid at room temperature.

The family of unsaturated fat includes two children: **monounsaturated fat** and **polyunsaturated fat**. In the polyunsaturated fat family, you will find omega-6 fatty acids and omega-3 fatty acids, and it is the omega-3 family that has been making headlines in the nutrition world.

2. Omega 3 and its Types

There are three types of fatty acids that are collectively called omega 3: **ALA (alpha-linolenic acid), EPA (eicosapentaenoic)** and **DHA (docosahexaenoic acid).**

Mega Health Benefits

- Extensive research has indicated that omega-3 fats reduce inflammation, helping to prevent inflammatory diseases like **heart disease** and **arthritis.** In addition to warding off inflammation, omega 3s are also **essential to the brain**, which impact behaviour and cognitive function, and are especially necessary during **foetal development**. According to the University of Maryland Medical Centre (UMM), omega 3s may also improve artery health by helping to **reduce plaque build-up and blood clots in arteries** that lead to the brain.
- Improve cholesterol with the lowering triglycerides and elevating HDL (good cholesterol) levels. These benefits come primarily from DHA and EPA. Improve joint health by reducing joint tenderness and stiffness associated with arthritis and osteoarthritis. Improve bone health by positively impacting the body's calcium levels, reducing the incidence of bone loss.
- Improve mental health by helping to insulate nerve cells in the brain, allowing these nerve cells to better communicate with one another. People who are deficient in omega 3s may suffer from depression, bipolar disorder, schizophrenia and eating disorders.
- Improve skin health by alleviating of symptoms related to skin disorders like acne and psoriasis.
- Improve bowel health by reducing inflammation of the bowels, helping alleviate symptoms of Crohn's disease and ulcerative colitis.
- Improve lung health by reducing inflammation in diseases like asthma. Improve menstrual health by reducing the pain associated with PMS (pre-menstrual syndrome) and menstruation.
- Help to **prevent cancer – colon, breast and prostate** cancers have all been correlated with low intakes of omega 3s.

Sources of Omega 3

The three different types of omega 3 are found in specific types of foods.

ALA is found primarily in foods of plant origin, but it is also found in other foods such as beef. The richest source of ALA is flaxseed, but it is also found in hempseed, canola oil, soybeans, soybean oil, pumpkin seeds, pumpkin seed oil, linseeds, walnuts and walnut oil.

Once ingested, the body converts ALA into EPA and DHA, allowing it to be more readily used by the body. However, this conversion is not very efficient. That is why experts recommend including EPA and DHA sources in your diet as well.

Facts Corner

DHA is found in seafood, algae and cold-water fish such as salmon, sardines and albacore tuna.

Note: Fish oil supplements and vegetarian DHA supplements (containing algae) are also available in liquid and capsule form, but always consult your health care provider before taking any supplements. Only use fish oil supplements that have been certified to be free of heavy metal contaminants like mercury.

EPA is found in many of the same foods as DHA, which includes cold-water fish such as salmon, and sardines, as well as cod liver, herring, mackerel and halibut.

Note: Fish oil and vegetarian algae supplements are also good sources of EPA, but always consult your health care provider before taking any supplements. Only use fish oil supplements that have been certified to be free of heavy metal contaminants like mercury.

Enriched eggs containing all three types of omega-3 fatty acids are readily available these days. These eggs are enriched by adding flaxseed or algae to the hen's diet so that they produce eggs that are rich in healthy fats. According to the Flax Council, omega-3-enriched eggs provide almost half of the recommended daily level of ALA and one-quarter of the recommended daily level of EPA and DHA – the same amount that can be found in 3 ounces of fish.

3. Good and Bad Cholesterol

- Cholesterol is a waxy, fat-like material, which is found in various parts of the body. It has two sources: the liver produces it, and we consume it in animal products, particularly meat and dairy products.
- There are two main types of cholesterol – HDL and LDL.
- **LDL cholesterol** is more likely to clog blood vessels because it carries the cholesterol away from the liver into the bloodstream, where it can stick to the blood vessels.
- **HDL (high-density lipoprotein) cholesterol**, on the other hand, carries the cholesterol back to the liver where it is broken down.
- LDL cholesterol is the bad kind, so call it 'lousy' cholesterol – 'l' for lousy. The HDL is the good cholesterol, so remember it as 'healthy' cholesterol – 'h' for healthy.
- Cholesterol floats around in your blood and can get into the walls of the blood vessels and stay there.
- If you have too much cholesterol in your bloodstream, it can collect in the blood vessel walls, causing these 'pipes' to become narrower. This can clog the blood vessels.
- If the clogging gets worse over many years, it can cause damage to important body parts, like the **heart (heart attack)** and **brain (stroke)**.

4. Trans Fat

Trans fat is created by a process called **hydrogenation,** which adds hydrogen molecules to highly unsaturated (liquid) oil, such as corn oil, vegetable oil, or soybean oil, etc. After hydrogenation, the oil is called 'partially hydrogenated' when listed on the package's ingredients list, and it contains trans fats.

Why do Manufacturers Use Hydrogenated Oils?

Earlier, manufacturers predominately used animal fats such as lard, beef tallow and butter when making baked and fried foods. Later, when scientists discovered that these saturated fats contributed to heart disease and 'bad' (LDL) cholesterol levels, food companies started to look for alternatives to these saturated fats.

Since hydrogenation makes oils more stable and solid at room temperature, this improves the baking characteristics of the liquid oil as well as the taste and texture of the end product. Partially hydrogenated oil provided a good alternative when it came to taste, texture and stability, and manufacturers started the use of these oils instead of animal fats. Years later, scientists discovered that both saturated fats and trans fats increase the risk for heart disease.

Which Products Contain Partially Hydrogenated Oil and Trans Fat?

Food products that contain trans fat are vegetable shortenings, harder stick **margarines, crackers, candies, cookies, snack, baking mixes and icing foods, fried foods, doughnuts, pastries and store-bought baked goods**. You may think that trans fat primarily comes from margarine, but margarine accounts for less than 20% of the trans fat in the average American's diet. Some meats and dairy products naturally contain small amounts of trans fat.

Note: Saturated fats, trans fats and cholesterol tend to raise 'bad' (LDL) cholesterol levels in the blood, which in turn increases the risk for heart disease.

KIDS AND FAT INTAKE

Although some people may think it is wise to try to cut fat altogether, it is crucial for fat to stay a part of a child's diet.

- For young kids, especially, fat and cholesterol play important roles in brain development.
- Ages 2 and under – fat should not be restricted.
- Ages 1 to 3 years – 30 to 35% of calories coming from fat.
- Ages 4 to 18 years – 25 to 35% of calories.

5. Food Safety and Standards Authority of India (FSSAI) Campaign

The Food Safety and Standards Authority of India (FSSAI) had launched a new mass media campaign called "Heart Attack Rewind", the 30 second public service announcement (PSA) – the first mass media campaign of its kind, in order to create awareness about trans fats and eliminate them in India by 2023.

Trans Fats

FSSAI launches ***'Trans-Fat Free' logo.*** This marked an important milestone in the movement against trans fats and also provided a momentum to accelerate ***the 'Eat Right India' movement*** of FSSAI.

Permissible Limit

WHO recommendation: Limited to less than 1% of total energy intake. It has called for ***the total elimination of TFAs in global food supply by 2023. FSSAI*** has proposed to limit TFA limit in foods to 2% and eliminate trans fats from foods by 2022.

Harmful Effects

- TFAs pose a higher risk of heart disease than saturated fats. While saturated fats raise total cholesterol levels, TFAs not only raise total cholesterol levels but also reduce the good cholesterol (HDL), which helps to protect us against heart disease. Trans-fats consumption increases the risk of developing heart disease and stroke.

WHO RECOMMENDATIONS

- In May 2018, WHO had released draft recommendations on limiting the intake of trans fats.
- These draft recommendations, the first since 2002, were aimed at controlling non-communicable diseases (NCDs), which were responsible for an estimated 39.5 million death (72%) of the 54.7 million deaths worldwide in 2016.

Key Recommendations

The recommendations are applicable to both adults and children.

- Saturated fatty acids should not comprise more than 10% of your daily calorie intake.
- Trans-fatty acids should not comprise more than 1% of your daily calorie intake.
- Use heart-healthy polyunsaturated fatty acids (PUFAs) as replacement.

- It is also associated with a higher risk of developing obesity, type 2 diabetes, heart disease, metabolic syndrome, insulin resistance, infertility, certain types of cancers and can also lead to compromised foetal development causing harm to the yet-to-be born baby.

Why they are being Increasingly Used?

- TFA containing oils can be preserved longer; they give the food the desired shape and texture and can easily substitute 'pure ghee'. These are comparatively far lower in cost and thus add to profit/saving.

INITIATIVE BY KERALA

Kerala has launched an initiative to enforce dietary guidelines, involving the reduction of trans-fatty acids (TFAs), salt and sugar in commercially available foods in the State. The initiative, with technical support from the World Bank, WHO and the Food Safety and Standards Authority of India (FSSAI), is launched as unhealthy diet is pushing up metabolic syndrome and premature deaths due to non-communicable diseases (NCDs) among Keralites.

26.29.9 Gluten Intolerance and Celiac Disease

In some people, mostly in children, gluten, a **type of protein triggers an autoimmune reaction** where the body produces antibodies that attack its own tissues.

A **mixture of gliadin and glutenin** causes inflammation and damage to the lining of the small intestine and results in Celiac disease or CD, which also goes by names like **gluten enteropathy, gluten sensitivity and idiopathic spruce.**

Besides **wheat**, the other major cereals containing this protein are **barley, rye** and to a lesser extent, **oats.**

Doctors have begun to call it an **'impending epidemic'.**

It is believed that the new strains of wheat that are cultivated nowadays have a highly antigenic gluten, unlike the traditional ancient varieties, which may have caused the rising incidence of the disease.

In milder forms of celiac disease, the **microvilli of the absorbing epithelial cells on the villi of the intestine are destroyed,** thereby decreasing the absorptive surface area as much as twofold. In more severe forms, the villi themselves become blunted or disappear altogether, further reducing its absorptive area.

More common in children, may include **abdominal bloating and pain, chronic diarrhoea, vomiting, constipation, pale foul smelling or fatty stools** and **weight loss.**

Besides, improper absorption of nutrients also causes malnutrition, hampering normal growth and development, leading to other problems like delayed growth, short stature, delayed puberty and enamel defects of the permanent teeth. Irritability is also a common feature in children. On the other hand, digestive symptoms are less prominent in adults who develop unexplained iron deficiency, **anaemia, fatigue, bone-joint pains, arthritis, bone loss, depression, anxiety, seizure and infertility**. Over time, they also get complications like **malnutrition, liver disease** and **cancer of the intestine**. The disease can be confirmed by **duodenal biopsy**.

The only treatment for celiac disease available at present is a strictly gluten-free diet, which requires avoiding wheat, barley, rye, oat and their derivatives, while depending completely on rice or corns as the staple food.

26.29.10 Milk Property and Milk Process

The milk goes through different processes, which can be called as **'dairy process'**. It is an industrial process in which milk components are separated and then re-constituted to produce desired milk products. From milking to consumption, milk may undergo a lot of dairy processes depending upon the product desired.

Let us look at some of these processes.

Cooling: Microorganism growth is prevented by immediately chilling the milk to 5°C or below. At this temperature, milk will retain its freshness for three to four days.

Standardisation: If milk has to be sold as buffalo milk, the minimum fat per cent should be standardised to 6% for most of the states in India. Milk may be standardised to full-cream milk, toned milk, double-toned milk etc.

- **Full-cream** milk should contain minimum 6.0% fat and 9.0% **solids not fat (SNF),** while standardised milk should contain minimum 4.5% fat and 8.5% SNF.
- **Toned milk** and **double-toned milk** should contain minimum 3.0% fat and 8.5% SNF and minimum 1.5% fat and 9.0% SNF, respectively.

Solids Not Fat (SNF): A substance in milk other than water and butterfat are termed as solids not fat (SNF). It is a residual component left after the complete evaporation of water from milk.

Pasteurisation: Pasteurisation eliminates all pathogens and most of the spoilage type of microorganisms. For this purpose, milk is heated to such a time–temperature combination that ensures destruction of even the most heat-resistant pathogen. Mycobacterium (TB germ) is the most heat-resistant pathogen and it is taken as the index for deciding pasteurisation temperature.

Pasteurisation may be done by two methods: **Low-temperature long time (LTLT)** or **high-temperature short time (HTST)**. Nowadays, the HTST method is mostly used. After pasteurisation, the milk must be immediately cooled down to 5°C or below so that the surviving microorganisms do not multiply further.

Cream separation: In cream separation process, fat is removed from the milk by passing it through a cream separator in which it is rotated at a very high speed (around 8000 revolutions per minute) in thin films. Milk cream or fat, being lighter (specific gravity 0.9), remains in the centre while the skimmed milk (skim milk contains the entire constituent except fat), being heavier (specific gravity 1.036), goes towards the periphery in the cream separator. The separated cream and milk are collected from different outlets provided in the cream separator.

Homogenisation: The fat in milk is present in shape of fat globules that are of different sizes. The size may vary from 0.1 to 22 microns and generally it is from 2 to 8 microns. Homogenisation is the process wherein fat globules are broken down mechanically to a **size of about one micron**. Homogenisation is generally used in reconstitution of milk and fat-rich products like **ice cream, condensed milk, sterilised flavoured milk** etc. Homogenised milk does not stick to the container and gives a viscous appearance and rich mouth taste.

Sterilisation: Some bacterial spores may not get destroyed even by boiling of milk. They are destroyed through sterilisation that is the process of heating milk to 120°C for 30 seconds or 150°C for 2–3 seconds so that a shelf-life of 6 months of milk at room temperature is ensured.

Adulteration in Milk

The most common adulteration in milk is water. This is added to increase the volume of milk during loose milk distribution.

The second category of adulterants are those, which are added to mask the adulteration of water in milk. These are added to increase the SNF level. The number of such adulterants is very large. The most common are **starch, matlodextrins, sugar, salt, urea** and a lot more.

In addition, traders may also add other chemicals to milk. When milk is transported to farther places for distribution, the bacteria in milk deteriorate it producing lactic acid. This lactic acid destabilises the proteins in milk and when such milk is heated, it gets coagulated. To prevent such curdling, traders add alkaline neutralisers like **caustic soda** and **sodium bicarbonate** so that the developed acidity is neutralised and milk does not curdle on heating. Another class of additives to milk may be preservatives. These are substances that have bacteriostatic or bactericidal effects and prevent the growth of microorganisms. This enhances the shelf-life of milk. But addition of these preservatives is illegal and such substances are harmful for human health. The most common preservatives are hydrogen peroxide and formalin.

26.29.11 Alternative to Sugars

Alternative sugars are those, which provide **sweet taste but very low or minimum calories.**

These artificial sweeteners are sometimes called as **non-nutritive sweeteners** because they do not provide energy.

There are different types of alternative sweeteners:

(A) **Artificial sweeteners:** These are synthetic sweeteners, like **Aspartame, Saccharin, Neotame, Alitmate, Acesulfame-k, Sucralose, Tagatose, Alitmate and cyclamate.**
(B) **Sugar replacers**
(C) **Herbal alternative: Stevia** (also popular with the name of **'Sugar Tulsi'**)

(A) Some important artificial sweeteners

Aspartame

- Aspartame contains two amino acids – **Aspartic acid** and **Phenyl alanine** with **methyl group**. It is 200 times sweeter than normal sugar.
- A person who is suffering with Phenylketonurics (PKU) should avoid aspartame because it contains aspartame. It is also dangerous for children. The accumulation of phenylalanine and its by-product is toxic for the nervous system and causes irreversible brain damage.
- During metabolism of Aspartame in human body, both amino acids are absorbed in human body as a source of energy but methyl group get metabolised and become methanol, formaldehyde and other toxic substances.
- Some researchers said that consumption of Aspartame also causes various other problems, like Fibromyalgia syndrome, multiple sclerosis symptoms, dizziness, headaches, menstrual problems etc.

Saccharin

- Saccharin, as an artificial sweetener, was banned earlier but now it got licence for human consumption by FDA (Food and Drug Administration), the US. Researchers said that saccharin with smoke is responsible for bladder cancer.
- It's made in a laboratory by oxidising the chemicals **o-toluene sulphonamide** or **phthalic anhydride.** It looks like white, crystalline powder.
- It is 200 to 700 times sweeter than table sugar (sucrose) and it does not contain any calories.

Note:

1. Sucralose, Acesulfame-K and Saccharin are not metabolised in the body but Aspartame digest as a protein in human body (4 kcalories per gram), but its energy contribution is very less.
2. The Food Safety and Standards Authority of India (FSSAI) has approved six artificial sweeteners, namely **saccharin sodium, aspartame, acesulfame potassium, sucralose, neotame and isomaltulose** for use in food.

(B) Sugar replacers

- Sugar replacers also provide calories, but fewer than their carbohydrate cousins, sugars. Sugar replacers yield some amount of energy, so they are also called as **nutritive sweeteners.**

- Sugar alcohols can be used as sugar replacers; they occur naturally in fruits and vegetables. They absorb very slowly in human body than conventional sugar.
- Sugar alcohol also has side effects like gas, abdominal discomfort and diarrhoea.
- There are various examples of sugar alcohol, those we are using in many food items like chewing-gum (Orbit), jams, jellies, cookies etc.: Erythritol, Isomalt, Lactitol, Maltitol, Mannitol, Sorbitol, Xylitol.

(C) Herbal alternative

- **Stevia** is a **natural sweetener** and **sugar substitute** derived from the leaves of the plant species Stevia rebaudiana, native to **Paraguay** and **Brazil**.
- The active compounds are **steviol glycosides**, which have about 50 to 300 times the sweetness of sugar. Stevia is heat-stable, pH-stable and not fermentable. The human body does not metabolise the glycosides in stevia, so it contains zero calories as a non-nutritive sweetener.
- Stevia is also popular with many names like **Meethi Tulsi** or **Meethi Patti** in Hindi and **Madhu Patra** in Sanskrit.

Some studies observed that Stevia had an 'inhibitory effect on bacterial communication' those contribute to an imbalance of good and bad bacteria in the gut, which can result in gastrointestinal symptoms like diarrhoea, gas and nausea.

Due to more duration of intake of Stevia trigger certain proteins those are responsible for inflammation in both the liver and kidneys, which over time could damage the organs.

Note: It has mixed opinion by researchers. In the United States, people are using it as a dietary supplement but not used as a food additive.

26.29.12 Anti-ageing

Anti-ageing is defined as to slowing, preventing or reversing the ageing process in human body. **Ayerst Laboratories** (a pharmaceutical company in Montreal) isolated a compound from a rare strain of bacteria ***Streptomyces hygroscopicus*** as anti-ageing compound. There are many reasons identified behind anti-ageing like Rapamycin drug, Calorie restriction, Resveratrol (red wine compound) etc.

(A) Rapamycin

- In 2009, a large National Institute of Health-funded study established that rapamycin and its derivative helped mice live longer. Male mice on rapamycin lived 9% longer. The female's lifespan was extended by 14%.
- Rapamycin acts on what is called the **mechanistic Target of Rapamycin (mTOR)** complex, a set of genes that acts as the cell growth regulating kinase. When mTOR is blocked, it can push cells into a life-extending survival mode.
- Giving such a drug to older patients, whose immune systems are often already diminished, would make them vulnerable to life-threating infections, defeating the purpose.

(B) Calorie Restriction

- The most well-known strategy to extend an animal's lifespan is **calorie restriction (CR)** or **dietary restriction (DR)**. Discovered about 70 years ago, CR involves reducing the calorie intake of an animal by 30–40% compared to its normal calorie intake.
- It is thought to lower metabolic rate and cause the body to generate fewer damaging free radicals.
- CR delays or prevents age-related diseases and extends lifespan in species ranging from yeast to primates. Evidence that CR retards ageing and extends median and a maximal lifespan was first presented in the 1930s.
- But radical dieting for calorie restriction is not a reasonable idea to increase lifespan among humans, for two reasons; firstly, because CR has shown to affect fertility of the organism in many cases; secondly, because the person would most likely die of starvation, if not of ageing.

(C) Resveratrol (Red Wine – Extending Life)

- **Resveratrol** is a phytoalexin polyphenol that is found naturally in the grape skins and is present at low concentrations in red wine, has shown diverse health benefits ranging from reducing the risk for heart disease and increasing human lifespan.
- **Resveratrol-Sir 2:** Resveratrol acts as an activator of **Silent information regulator 2 (Sir2)** proteins, or **sirtuins**. When an extra copy of the SIR 2 gene was added to the yeast **S. ceravisiae**, the formation of extra chromosomal rDNA circles was repressed

which led to a 30% extension in the cell's lifespan. Mammals possess seven types of sirtuins, SIR T1 to 7.

THE LONG-LIVING JEWS

There is a historically isolated and culturally insular population from Eastern and Central Europe, known as the **Ashkenazi Jews**. It has been observed that these Jews unusually tend to live longer and suffer from less cardiovascular problems compared to other populations. The secret of this interesting group of people could help us pinpoint the longevity genes responsible for ageing.

- Researchers at Yeshiva University's Albert Einstein School of Medicine examined 477 Ashkenazi Jews, looking for factors that may have contributed to their longevity. They observed that the Ashkenazi Jews who have crossed the age of 95, are more likely to possess a genetic variant that down-regulates insulin-like growth factor 1 (IGF-1). Studies suggest that such mutations could be responsible for delaying old age.
- Disruption of IGF-1 has caused an increase in the lifespan of mice by 30–40%.
- Some scientists are of the opinion that Sir2 which regulates the low metabolic state of calorie restriction may be part of the IGF-1 pathway.
- The complex interlinked dynamics of calorie restriction, Sirtuins, IGF1 and many other 'longevity genes' presents itself like a puzzle before scientists, that needs to be solved if any serious progress can be made in fighting ageing.

26.29.13 e-Cigarettes and Related Statute

An **electronic cigarette (or e-cig)** is a **battery-powered vaporiser** that **mimics tobacco smoking**. It works by heating up a nicotine liquid, called 'juice'. Nicotine juice (or e-juice) comes in various flavours and nicotine levels.

e-liquid is composed of five ingredients: vegetable glycerin (a material used in all types of food and personal care products, like toothpaste) and **propylene glycol** (a solvent most commonly used in fog machines). It is due to the propylene glycol, the thicker clouds of vapour are produced. **Proponents** of e-cigarettes argue that the practice is **healthier than traditional cigarettes** because **users are only inhaling water vapour and nicotine.**

The **Indian Council of Medical Research (ICMR) has recommended 'complete' ban on electronic nicotine delivery systems (ENDS),** including e-cigarettes. The recommendation is based on currently available scientific evidence.

Why ICMR has recommended a complete ban?

- **Addictive in nature**
- **Use of ENDS or e-cigarettes can open a gateway for new tobacco addiction**
- Adverse impact on humans which includes **DNA damage, respiratory/cardiovascular/neurological disorders, carcinogenic/cellular/molecular/immunological toxicity and even have adverse effects on foetal development and pregnancy**

Why is it Hard to Regulate Them?

- As e-cigarettes contain nicotine and not tobacco, they do not fall within the category of the **Cigarettes and Other Tobacco Products (Prohibition of Advertisement and Regulation of Trade and Commerce, Production, Supply and Distribution) Act, 2003 (COTPA)**, which mandates stringent health warnings on the packaging and advertisements of tobacco products.
- **Need for regulation:** The current unregulated sale of e-cigarettes is dangerous for a country like India where the number of smokers is on the decline (WHO Global Report, 2015) as it increases the possibility of e-cigarettes becoming a gateway for smoking by inducing nicotine addiction and perpetuating smoking by making it more attractive, thereby encouraging persons to become users of tobacco as well as e-cigarettes.

Prohibition of Electronic Cigarettes Ordinance

Cabinet approves promulgation of **the Prohibition of Electronic Cigarettes (production, manufacture, import, export, transport, sale, distribution, storage and advertisement) Ordinance, 2019.**

Upon Promulgation of the Ordinance

- Any production, manufacturing, import, export, transport, sale (including online sale), distribution or advertisement (including online advertisement) of e-cigarettes shall be a cognizable offence.
- It shall be punishable with an imprisonment of up to one year or fine up to ₹1 lakh or both for the first offence; and imprisonment of up to three years and fine up to ₹5 lakh for a subsequent offence.

- Storage of electronic-cigarettes shall also be punishable with an imprisonment up to 6 months or fine up to ₹50,000 or both.
- The owners of existing stocks of e-cigarettes on the date of commencement of the Ordinance will have to suo moto declare and deposit these stocks with the nearest police station.

Implementation

- The Sub-Inspector of Police has been designated as the Authorised Officer to take action under the Ordinance.
- The Central or State Governments may also designate any other equivalent officer(s) as Authorised Officer for enforcement of the provisions of the Ordinance.

Challenges Ahead

- **Drugs Consultative Committee ('DCC')** has recommended a complete ban on the manufacture and import of ENDS under **sections 26A and 10A of the Drugs and Cosmetics Act, 1940.**
- Interestingly, **the Delhi High Court and the Bombay High Court in their orders dated 18 March 2019 and 25 July 2019, respectively, had held that ENDS were not drugs and therefore could not be banned under the Drugs and Cosmetics Act, 1940** and hence no proceedings could be initiated against the manufacturers, sellers and importers of ENDS.
- There is, therefore, **a clear inconsistency and conflict when it comes to the stand taken by the Central government and the courts.**

26.29.14 Fortified Rice

Fortification is **the practice of deliberately increasing the content of an essential micronutrient,** i.e., vitamins and minerals (including trace elements) in a food, in order to improve the nutritional quality of the food supply and provide a public health benefit with minimal risk to health.

Rice Fortification

- Rice is the world's most important staple food. An estimated 2 billion people eat rice every day, forming the mainstay of diets across large part of Asia and Africa.
- Regular milled rice is low in micronutrients and serves primarily as a source of carbohydrate only. The fortification of rice is a major opportunity to improve nutrition.
- Fortified rice contains vitamin A, vitamin B1, vitamin B12, folic acid, iron and zinc.

Food Fortification in India

- **Food Safety and Standards Authority of India (FSSAI)** has formulated a comprehensive regulation on fortification of foods namely **'Food Safety and Standards (Fortification of Foods) Regulations, 2016'.** These regulations set the standards for food fortification and encourage the production, manufacture, distribution, sale and consumption of fortified foods.
- The regulations also provide for specific role of FSSAI in promotion for food fortification and to make fortification mandatory. This sets the premise for the national summit on fortification of food.

Benefits of Fortification

- If consumed on a regular and frequent basis, fortified foods will maintain body stores of nutrients more efficiently and more effectively than will intermittent supplements.
- Fortified foods are also better at lowering the risk of the multiple deficiencies that can result from seasonal deficits in the food supply or a poor quality diet.
- Fortification can be an excellent way of increasing the content of vitamins in breast milk and thus reducing the need for supplementation in postpartum women and infants.
- Fortification of widely distributed and widely consumed foods has the potential to improve the nutritional status of a large proportion of the population, both poor and wealthy.
- Fortification is often more cost-effective than other strategies, especially if the technology already exists and if an appropriate food distribution system is in place.

To tackle the menace of malnutrition, NITI Aayog seeks creation of roadmap by Department of Food and Public Distribution for taking **the Rice Fortification Pilot Scheme** Pan India.

26.29.15 Triclosan

Triclosan is a common ingredient found in many **grooming products, including facial washes, toothpaste and deodorants.** However, it is mainly found in **antibacterial hand washes, soaps, gels and household cleaners.**

Triclosan is an ingredient added to many consumer products intended **to reduce or prevent bacterial contamination.**

Some short-term animal studies have shown that exposure to high doses of triclosan is associated with a decrease in the levels of some thyroid hormones. Other studies have raised the possibility that exposure to triclosan contributes to **making bacteria resistant to antibiotics.** One is a study investigating the potential of developing **skin cancer after a long-term exposure** to triclosan in animals.

In 1997, FDA reviewed extensive effectiveness data on triclosan in Colgate toothpaste. The evidence showed that triclosan in that product was effective in preventing gingivitis.

Regulation on Triclosan under FDA (Food and Drug Administration)

1. Triclosan is **an ingredient added to many consumer products intended to reduce or prevent bacterial contamination.**
2. **The antibacterial compound triclosan has been linked to numerous human health problems.** Exposures come mainly by absorption through the skin or through the lining of the mouth. These exposures have resulted in contact dermatitis, or skin irritation, and an increase in allergic reactions, especially in children.
3. Triclosan **functions as an antimicrobial agent by impairing the production of bacterial lipids.** More specifically, it blocks the active site of a bacterial enzyme known as enoyl-acyl carrier protein reductase. Since humans lack this enzyme, triclosan has been generally accepted as harmless to human health.
4. **Effects of triclosan:** The use of triclosan is linked to the following effects on human health: **Abnormal endocrine system/thyroid hormone signalling. Weakening of immune system.** Children exposed to antibacterial products at an early age have an increased chance of developing allergies, asthma and eczema.
5. **Colgate remove triclosan:** Researchers examined the antibacterial compound triclosan, which federal authorities banned in over-the-counter products like antibacterial soaps and gels in 2016 after **manufacturers were unable to prove it was safe for long-term use or more effective at preventing infection spread than soap and water.**
6. **Is triclosan a carcinogen?** Triclosan, found in antibacterial soap and other products, causes cancer in mice. Long-term exposure to triclosan – an antibacterial ingredient found in some soap, toothpaste and other common household products – **may lead to liver cancer in mice,** according to a new study.

Note: India lacks any such regulation so far on the use of Triclosan-based products.

26.29.16 Polyethylene Terephthalate (PET)

Polyethylene terephthalate is the chemical name of **polyester.** It is a clear, strong and lightweight plastic which is widely used for **packaging of foods and beverages, usually convenience-sized soft drinks, juices and water.**

They are often used in durable-press blends with other fibres such as rayon, wool, cotton and reinforcing the inherent properties.

PET plastic is the **recyclable plastic** and **BPA free.** But still PET is not safe and creates various health risks such as stunted growth, reproduction issues, low energy levels, body balance issues and inability to process stress. **Maharashtra government has announced the ban on sale of alcohol in PET bottles because alcoholic beverages have carbonated material.**

PET an inert material is **widely accepted by health authorities also as a safe plastic,** which is one of the reasons it is so commonly used in food and beverage packageing. Similar to glass **it is hygienic and generally resistant to attack by bacteria and other microorganisms.**

PET made material is 60–70% degraded within 6 months but not completely biodegradable as a **non-biodegradable polymer.**

PET is known to leach antimony trioxide and phthalates. Both of these are dangerous to health. While antimony may contribute to cancer development, skin problems, menstrual and pregnancy issues, phthalates are endocrine disruptors. So the use of PET has mixed declarations by the corporate sector and scientists.

26.29.17 Rice Bran Oil

Department of Food and Public Distribution launched National Agricultural Cooperative Marketing Federation of India Ltd. **(NAFED)** Fortified Rice Bran Oil. NAFED comes under the Ministry of Agriculture and deals with marketing cooperatives for agricultural produce in India.

It is popularly known as **heart oil** and also health food in western world. Rice bran oil is derived from rice. Rice has several layers; the outermost layer is called bran. Bran is a brown coloured, hard and oily layer between the rice kernel and the outer husk. The rice bran oil comes from the bran.

Rice bran oil is not sticky, thus edible and suitable for cooking. Rice bran oil is a natural source of a powerful antioxidant, **Oryzanol** (studies claim that Oryzanol assists in **reducing cardiovascular diseases**). Rice bran oil is nutritionally rich and has mild flavour.

It has a high-smoking point of 232°C (450°F) which makes it useful for high heat cooking like stir frying, deep frying etc. This means the oil retains its nutrition even at high temperatures. Rice bran oil can also be used for nourishing, cleansing and brightening skin.

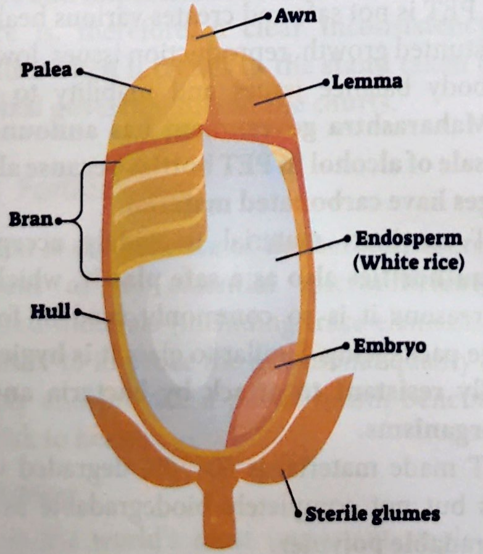


Figure 26.6
Composition of Rice Grain

COMPOSITION OF RICE BRAN OIL

One table spoon of rice bran oil contains
- Calories: 120
- Protein: 0 grams
- Fat: 14 grams
- Carbohydrates: 0 grams
- Fibre: 0 grams
- Sugar: 0 grams

Rice bran oil is a good source of
- Vitamin E
- Vitamin K

Health Benefits of Rice Bran Oil

- Helps improve cholesterol, blood sugar levels and blood pressure.
- Helps maintain a healthy heart: **The striking balance of monounsaturated and polyunsaturated fats in rice bran oil makes it healthy for the heart.**
- Helps reduce post-menopause symptoms.
- Enhances vitamin E levels: **It also acts as an immunity booster and reduces the risk of cancer due to the high amount of vitamin E it contains.**
- Excellent supplement to regulate thyroid functioning.
- Helps decrease calcium absorption in kidneys and prevents stone formation.
- This oil is recommended by The American Heart Association and the World Health Organization (WHO) as one of the best substitutes for other edible oils.

NAFED Fortified Rice Bran Oil

- Rice bran oil from NAFED will be fortified and it will contain additional nutrients and vitamins and will be marketed by NAFED.
- According to the FSSAI, fortified oil can help a person fulfil 25–30% of the recommended dietary intake for vitamins A and D.
- NAFED fortified rice bran oil will be available at all NAFED stores and also on various online platforms.

Significance

- This initiative by NAFED will significantly reduce the country's consumption dependence on imported edible oils in future.

- It will provide easy access to NAFED branded high quality rice bran oil, which will also give a boost to the indigenous oil manufacturing industries.
- It will further give an impetus to the Prime Minister's *Aatmanirbhar Bharat* initiative.

Side-Effects of Rice Bran Oil

- Increasing the amount of bran in the diet can cause unpredictable bowel movements, intestinal gas and stomach discomfort.
- People having gastrointestinal conditions or digestive tract problem such as intestinal ulcers, adhesions, conditions that cause narrowing or blockage of the digestive tract, slow digestion, or other stomach or intestinal disorders are not recommended to use rice bran oil.
- The fibre in rice bran can block your digestive tract causing indigestion.

PART B

2017 MAINS ANSWERS

2018 MAINS ANSWERS

2019 MAINS ANSWERS

2020 MAINS ANSWERS

2021 MAINS ANSWERS

2022 MAINS ANSWERS

2017 MAIN ANSWERS

1. **Give an account of the growth and development of nuclear science and technology in India. What are the advantages of fast breeder reactor programme in India?**

Ans: India's three-stage nuclear power programme was designed by Homi Bhabha in the year 1950 in order to cater the utilisation of thorium reserve of India which accounts for twenty-five per cent global thorium reserves and further make the country independent in nuclear technology. According to IAEA, India has limited uranium reserves amounting to 1–2% of global uranium reserves which are only sufficient to produce nearly 10 GWe of nuclear energy for forty years. Accordingly, India planned its three-stage thorium fuel plan for making country independent in nuclear energy.

In the first stage of three-stage nuclear program, country planned the construction of indigenously engineered pressurised heavy-water reactors (PHWRs) and light-water reactors to produce plutonium 239 as a by-product and also recently announced the building of 10700 MW PHWR.

In the second stage, a fast breeder's reactor (FBR) utilises mixed oxide fuel (MOX) produced from plutonium 239 from first stage and is designed to breed uranium 233 used in third stage from thorium. Presently, the country is focusing on the second stage.

In the third stage, the country will use advanced heavy-water reactors for producing nuclear energy and will be fuelled with U-233 obtained from the breeding of thorium in PHWRs and fast reactors.

Fast Breeders Reactors

Fast breeder reactors have to be used in the *second step* to support India's long-term goal of utilising its abundant thorium reserve by using the plutonium produced in pressurised heavy water reactors and breeding fissile uranium-233 from thorium. India has the world's largest thorium reserves which can produce nuclear power for more than 10,000 years or as long as 60,000 years. The world's only fast-breeder reactor is located in the Russia's Ural Mountains at the Beloyarsk Nuclear Power Plant in the city of Yekateringburg.

Presently, the **Prototype Fast Breeder Reactor (PFBR)**, a fast breeder nuclear reactor having capacity of 500 MWe is being constructed at the Madras Atomic Power Station in Kalpakkam, India and the Indira Gandhi Centre for Atomic Research (IGCAR) is given the responsible for reactor's design of this reactor. The PFBR is part of the India's three-stage nuclear power program. Apart from this, the government is planning to build four more fast-breeder reactors and presently, the reactor is in final stage to go critical.

Advantages of Fast Breeder Reactor Programme in India

Breeding Concept

FBR produces 30% more fuel than it consumes. It can obtain the high fissile material production that can be used to fuel another reactor. Therefore, it is easy to alter the breeding ratio in the FBRs by enhancing the number of neutrons. FBRs use small cores which are important to maintain the chain reaction and they do not require moderators for slowing down of neutrons as they use fast neutrons.

Economic Concept

Due to high operating temperature of the FBRs, they have high thermodynamic efficiency which results in reduced thermal pollution to the environment. Moreover, FBRs generate more energy than the conventional thermal power plant such as 3g of uranium on fission can produce ten times the energy as generated by a ton of coal.

Waste Management

In FBRS, the waste management burdens are nearly 200 times less than that of other conventional nuclear reactors. FBRs use the uranium waste from uranium processing plants and used fuel from other conventional nuclear reactors which easily manages their nuclear waste. Due to the use of reused fuel in FBRs, the mining and processing expense is also minimised.

Specific to India's Context

India has limited uranium reserves and has plentiful thorium reserves. Hence, FBRs are important due to their ability of effective and efficient utilisation of uranium reserves and also play an important role in the exploitation of country's thorium reserves. Moreover, the Uranium-235 used in LWRs is rare on earth whereas on the other side Uranium 238 used in FBRs is abundant on earth.

Moreover, thorium cannot be straight away used as a nuclear fuel but it can breed to give fissile isotopes (U233) by placing blanket. Further, premature introduction of thorium at a particular stage can result in a very low generation peak power load. Hence, use of thorium has to be done in a timely manner in order to accelerate the growth in next stage.

2. **Stem cell therapy is gaining popularity in India to treat a wide variety of medical conditions including leukaemia, thalassaemia, damaged cornea and severe burns. Describe briefly what stem cell therapy is and what advantages it has over other treatments.**

Ans: Stem cell is an undifferentiated cell that divides itself to produce more mature functional cells. Stem cells are generally found in multicellular organisms. In stem cells, there are two types – one is embryonic cell isolated from the inner cell mass of blastocysts and another one is adult stem cells which are found in various tissues in the body and are used to treat or cure the disease. In adults, stem cells act as a repair system of the body. There are three known sources of adult stem cells in the body–bone marrow, adipose tissues and blood. Stem cells can also be taken from umbilical cord blood after the birth. Moreover, embryonic stem cells can produce themselves into any body cells and are more versatile than adult stem cells.

Stem-Cell Therapy

It is a type of therapy in which stem cells are used to treat or prevent a disease other than any conventional method of treatment. Transplant of bone marrow is the most commonly used stem cell therapy. In the basic process of stem cell therapy, doctors take out bone marrow or adipose tissue and further process the stem cells in the lab. Thereafter, the stem cells are manipulated to specialise into specific type of stem cells such as heart muscles, nerve or blood cells, which can be implanted in a person. In some cases, bone marrow cells are specialised and manipulated to become heart cells which can repair the damaged heart tissue. Most of the stem cell therapies for the treatment of diseases like Parkinson, cardiac failure, neurological disorders, etc., are still in research stage.

Advantages of Stem Cell Therapy

Medical Benefits

Stem cell therapy gives a lot of medical benefits in the sector of regenerative medicine and therapeutic cloning. It has a great potential in the cure of various diseases which are not possible to cure with the present methods such as Parkinson's disease, Alzheimer's disease, diabetes, cancer, etc.

Human Growth Knowledge

It helps the researchers to know more about the human cells growth and their development which is vital for medical processes in curing of disease. Stem cells are used to grow limbs and organs in the lab and further used in transplant or treatment.

New Drugs and Medicines Testing

Stem cells can be used in future for testing of number of new medicines and drugs without making use of any animals and humans and can be tested directly on cells population.

Age Reversal

Stem cells are used in regenerative processes by reviving organs in our body which could have worn out or become old and can enhance the life/age of humans. Hence, age reversal can be possible with stem cells by providing replacement cells for curing of diseases.

Curing of Development Defects

It helps in the study of development stages which cannot be directly known through human embryo and further used in the treatment of various birth defects, infertility problems and pregnancy loss. It is also further used in the treatment of abnormal development in the human body.

Burn Patients

Stem cell therapy could be used to produce new and healthy tissues in burn victims which will reduce the pain of burn victims by removing specific stem cells from tissues and then transplanting them back to patients for replacement of damaged tissues.

Reduces Risk of Rejection

Stem cell has the uniqueness to become any cell in the body and further has the ability to keep on renewing itself. Therefore, in stem cell therapy, a patient's own cell can be used to treat the patient himself with the usage of adult stem cells and this further reduces the risk of rejection.

3. **India has achieved remarkable successes in unmanned space missions including the Chandrayaan and Mars Orbiter Mission, but has not ventured into manned space missions. What are the main obstacles to launch a manned space mission, both in terms of technology and logistics? Examine critically. (150 words, 10 marks)**

Ans: In 1984, Rakesh Sharma was the first Indian to enter the space as a part of first Indo-Soviet joint space mission. In the next two decades, no Indian human space flight or manned space mission took off. In the year 2009, ISRO chairman G Madhvan Nair announced that India is planning for a manned space mission and it will take place from Satish Dhawan Space Centre in Sriharikota. The plan visualised sending a two to three men crew in a three-ton spacecraft to low earth orbit which is up to 2000 km. The rocket would be GSLV launch vehicle and the project cost was estimated to be approximately ₹13,000 crores with scheduled launch in the year 2016. The government allotted ₹95 crores for pre-project studies till the year 2012. The government has also earmarked around 140 acres near Bengaluru airport for setting the astronauts training centre. Despite all these efforts, the project is still on paper as still there are no clear guidelines regarding the crew selection for manned space mission. Moreover, the government has also not given its nod for manned space mission.

Possible Obstacles in Manned Space Mission

Funds Requirement

In reality, it is very difficult for a country like India who is having a population of 130 crores and whose 22 per cent of population under poverty line; to spend money for such high investment manned mission projects. For achieving the goal of human space programme, ISRO requires funds and it is very difficult for the government to allocate funds annually for such types of manned space mission in the annual budget every year which is presently one of the biggest constraints in country's first manned space mission. NASA gets an investment of nearly 18–19 billion USD every year whereas ISRO gets only 1 billion USD.

Government Support

The government has to give its formal nod for the manned space mission and its support is very much required in order to achieve the country's first space mission. The mission is not included in 12th Five year (2012–17) plan but human space flight (HSF) programme may be included in 13th Five year plan (2017–22)

Technological Constraints

There is a lot of technological gap between India and other countries such as Russia and USA in terms of space shuttle, international space station in which the other countries are miles ahead as compared to India.

Astronaut Training Centre

Other technology aspects for HSF programme pertain to setting up the facility for training of astronauts and equipping it with human centrifuge machines, zero-gravity simulators, etc., so that the astronauts can be trained for manned space mission.

Selection of Astronauts

Selection of astronauts is also a crucial and vague task as there is always a competition between ISRO scientists and Indian Airforce Fighter Pilots for the selection of astronauts.

Critical Technological System

For achieving the goal of Human Space Programme, following are the critical technological system requirements.

(a) Crew model system has to be developed for flight testing of unmanned flight.
(b) Crew escape system has to be developed and its performance has to be demonstrated.
(c) Environment control and life support system and flight suit.
(d) Living space capsule model

4. How does the Juno Mission of NASA help to understand the origin and evolution of Earth?
(150 words, 10 marks)

Ans: Juno is a NASA space probe which orbits around Jupiter planet, operated by the jet propulsion laboratory of NASA and was launched on 5 August 2011. The spacecraft reached the planet Jupiter's orbit on 5 July 2016 for the scientific study of the planet. It was launched to examine the composition, gravity and magnetic field, the data regarding the formation of planet and its environment, high winds and its distribution of mass. The mission major role is to study the Jupiter's origin and evolution which can also lead to the study of other planetary system studies.

Juno Study for Earth Origin and Evolution

Except Jupiter, no other planets in the solar system can depict the formation and initiation of the Earth planet.

- Formation of Jupiter is the initial a transitional step among the star and the solar system formation.
- After the formation of solar system and Sun, Jupiter with the help of its huge gravitational force had shaped the solar system, thereby removing the comets, asteroids and small planet forming particles.
- Jupiter ancient dust bursting activity led to the formation of Mercury, Venus, Earth and Mars planets.
- With the help of Juno, the availability of nitrogen as ammonia and oxygen as water in the solar system in primordial times can be determined, thereby, making them the important planets in the formation of earth.
- The Juno will help in studying the Jupiter's core features and elements, assuming the planet core's temperature to be hotter than the Sun's temperature and pressure greater than the Earth's atmosphere, may be consisting that of hydrogen and helium gas for the ultimate study of planet's magnetic field evolution.
- Juno will help in the study of the Jupiter's strongest magnetic field, being 20,000 times stronger than the Earth termed as magnetosphere, ultimately studying the space weather including its formation.
- As per the study of Juno, the huge gravitational field of Jupiter has ejected the icy comets or other icy material consisting of water, oxygen and other small volatile materials which help in the formation of Earth's and various terrestrial planet's atmosphere and hydrosphere.
- Juno will help in the study the Jupiter's strong gravity and magnetic field on the moon and further assist in understanding moon's future relation with Earth and the solar system.

2018 MAIN ANSWERS

5. Discuss the work of 'Bose-Einstein Statistics' done by Prof. Satyendra Nath Bose and show how it revolutionised the field of physics.
(150 words)

Ans:

Bose-Einstein Statistics

- Particles that have an integer spin such as photons, several atoms, such as Gluon, W and Z boson and Higgs boson, fall under those categories of particles that show quantum mechanical behaviour, but do not obey the Pauli's exclusion principle. Such particles have integer values of spin and there must also be no significant interaction between the particles. The statistical behaviours of these particles was described by Satyendra Nath Bose, and Albert Einstein, and goes by their names as Bose-Einstein statistics. Particles obeying these statistics are called Bosons. Bosons, are particles with an intrinsic spin of 0, 1, 2 or another integer.

- There are various particles such as electron, proton, neutron, neutrino, and photon. All the particles in this list, except the photon, are so-called matter particles. The photon, on the other hand, is a quantum, or tiny bundle, of the electromagnetic field.
- The relation between matter particles and field quanta is simple as matter particles interact with each other by exchanging the appropriate field quanta.
- One fundamental difference between matter particles and field quanta is that while many field quanta can be squeezed into a small volume, but the same is not possible with matter. For example, while sitting close to another person, there is a limit to how close you can get. This is because the electrons, protons, etc., in our bodies resist being stacked on top of each other. The same is not the case with field quanta, which can be as closely packed as needed.
- Matter particles such as electrons, protons, etc., obey what is known as the Fermi-Dirac statistics and hence, are known as 'Fermions'. The fermions, governed by Fermi-Dirac statistics, are all particles with odd-half-integer spins -- ½, 3/2, 5/2, etc., – and include the electrons, neutrinos, muons and all the quarks, the fundamental particles that make up protons and neutrons.
- Bosons particles at low temperatures, cause such strange phenomena as superconductivity, super fluidity and Bose-Einstein condensation. They also allow photons of the same frequency to form coherent laser beams. Fermions, on the other hand, avoid one another. Electrons around a nucleus stack into shells instead of collapsing into a condensed cloud, giving rise to atoms with a great range of chemical properties.
- Field quanta, obey what is called Bose-Einstein Statistics and are collectively called 'Bosons'. There is the Higgs boson which gives mass to particles like protons and neutrons after they collide in Higgs field. There are the W and Z bosons associated with the weak force and the neutrinos which cause the particle to change and decay. Gluon is responsible for strong force which holds the nuclei together.
- The Bose-Einstein distribution predicts that at very low temperatures, nearly absolute zero, all particles in the system will condense into a single state, called the Bose-Einstein condensate. This was a prediction made around the year 1924. At that time, the experimental facilities available were not capable of attaining the low temperatures required to test this prediction. It took almost seventy years from the time of the prediction, for experimental facilities to evolve to the stage where it was possible to demonstrate the formation of this condensate. In 1995, Eric Cornell and Carl Wieman, demonstrated the formation of the condensate using a small collection of Rb atoms, which they cooled to a few hundred nano Kelvin. For demonstrating the formation of the Bose-Einstein condensate, they were awarded the Nobel prize in Physics for the year 2001 along with Wolfgang Ketterle.
- It was Bose who actually figured out (in the specific case of photons) how a group of identical photons will behave.
- Bose was interested in reproducing, mathematically, Planck's law of radiation using only quantum mechanical ideas and therefore, he employed a technique in this calculation that laid the foundation of quantum statistics. He then sent his paper to Albert Einstein who recognised the value of his calculation and had the paper translated into German and published in the journal *Zeitschrift fur Physik*. This paper turned out to a seminal one and the technique used by Bose goes under the name of Bose-Einstein Statistics and the particles such as photons that obey these statistics are called bosons.
- While Bose himself did not realise the enormous breakthrough he had made, Einstein did, and he took Bose's work much further. Physicist Paul Dirac was the first to use the term "boson" to describe the particles that obeyed Bose-Einstein statistics, in order to celebrate Bose's contribution to developing this theory.

It revolutionised the field of Physics in two ways:

- ◆ Improved the benchmark in terms of particle Physics model.

- Laid the foundation of 'God Particle' and helped Peter Higgs in winning a Nobel Prize.

Enhanced the benchmark of Standard Model of Particle Physics

- Bose-Einstein statistics predicted that at very low temperature near absolute zero, all particles will condense into a single state, called Boson. This was a prediction made in 1920s. At that time, the experimental facilities were not capable of attaining the low temperatures to test such prediction.
- Over the years, experiments related to Bose-Einstein Statistics were carried out. Resultantly, all the fundamental particles were classified into two categories, the first one is "Fermions" after an Italian scientist Enrico Fermi, and the second one is "Bosons" after the Indian scientist Prof. Bose.
- Thus, "Bose-Einstein Statistics" helped improving the benchmark in terms of Standard Model of Particle Physics.

Discovery of God Particle

- Peter Higgs carried out further research in the year 1960 using Bose-Einstein Statistics and wrote a paper about a very unstable particle that survives for a fraction of a second after its birth, and then it breaks apart producing other fundamental particles. He termed this particle "Higgs Boson Particle" or "God Particle". If scientists could produce such "God Particle" in laboratory, it could further improve the Standard Model and our understanding of the universe.
- In early 2000s, World's largest particle accelerator called 'Large Hadron Collider (LHC)' was setup at CERN's laboratory in Europe. They carried out experiments and successfully discovered the God particle and confirmed the theory of Peter Higgs.
- Subsequently, Peter Higgs was given a Nobel Prize in Physics (2013).

The Bose-Einstein Statistics helped CERN scientists discover God particle and thus, improved the Standard Model of Particle Physics and our understanding of the Universe.

6. **Why is there so much activity in the field of bio-technology in our country? How has this activity benefitted the field of biopharma?**

(250 words, 15 marks)

Ans: The recent breakthroughs in biotechnology offer the great potential for progress in fields such as healthcare, agriculture, and environmental conservation. Biotechnology has great potential in India, where radical product development and research is under way in spite of an emerging market and industry. Particularly, these three areas such as biopharmaceuticals, bio agriculture, and bio services have significantly focused the growth in India's biotech sector. These swift innovations in the biotechnology field have the potential to improve the lives of people around the world in areas, including agriculture, environmental conservation, healthcare and disease treatment, big data–driven bioinformatics, and industrial biotechnology. Besides this, the areas of research consist of stem cell research, embryo research, genetic engineering, synthetic biology and tissue engineering which may be very useful in future prospects. Various recent initiatives have been taken in the biotechnology field such as promoting transgenic research in plants with emphasis on pest and disease resistance, nutritional quality, silk-worm genome analysis, etc., launching of National BioPharma Mission, manufacturing of malaria and dengue vaccine, launching of biotech-kisan scheme, production of ethanol from biomass and BIO-CNG, etc. Advances in biotechnology will help in the better understanding about the process of inheritance and gene expression, treatment of various diseases, mainly genetic disorders. These major advances pave the way for the enhanced number of activities in the field of biotechnology.

Biopharma

- The Government of India launched the National Biopharma Mission with the help of Department of Biotechnology and the Mission was approved by the Cabinet for implementation in May 2017 with a total cost US$ 250 million which is fifty per cent co-funded by World Bank. Therefore, to create a globally competitive biopharmaceutical industry that addresses the country's major concerns around barriers to affordable healthcare, Union Ministry of Science & Technology, launched the Innovate in India (I3) program (National Biopharma Mission) on 30 June 2017.
- This flagship program of the Government of India, with a funding to the tune of US$ 250 million, in collaboration with the World Bank,

will be implemented by the Biotechnology Industry Research Assistance Council (BIRAC), a Public-Sector Enterprise set up by DBT. The mission aims to create an enabling ecosystem to promote entrepreneurship and indigenous drug manufacturing and committed to make India a hub for development of affordable and effective biopharmaceutical products. This will accelerate discovery research to early development for biopharmaceuticals.

- The programme will specifically focus on the development of new vaccines, bio-therapeutics, diagnostics and medical devices to better address the rising burden of diseases in the country. It will also bring isolated centres of excellence together, enhance regional capabilities and strengthen the current bio-clusters network in terms of capacities as well as quantity and quality of output.

The significance of the mission lies in the fact that National Biotechnology Development Strategy 2015–2020 announced by the Department of Biotechnology (DBT) lays emphasis on making the country achieve 100 billion USD biotech industry by 2025.

7. **With the growing energy needs should India keep on expanding its nuclear energy programme? Discuss the facts and fears associated with nuclear energy. (250 words, 15 marks)**

Ans: India should keep on expanding its nuclear energy programme. The main reasons behind this are as follows:

- India is the fourth largest consumer of energy after the USA, China, and Russia, but it is not capable with plentiful energy resources. It must, therefore, meet its development needs by using all available domestic resources of coal, uranium, oil, hydro, and other renewable resources.
- India's energy poverty is a big challenge. As per a survey, nineteen per cent of India's population is without the access to electricity .
- Coal is the primary source of energy in India but has increased the emission of Green Houses Gases (mainly CO_2) and which is leading to climate change and playing a significant role in global warming. So replacement of coal fully or to some extent is the need of the hour.
- Nuclear energy's emission free nature can contribute to global efforts under Paris Agreement decided at the Conference of Parties (COP) 21 meeting to confrontation climate change by restricting its total carbon emissions.
- India's Nationally Determined Contribution (NDC) to the United Nations Framework Convention on Climate Change (UNFCCC) has outlined goals to reduce the carbon emissions intensity of its economy by 33–35 per cent by 2030 as well as increase the clean energy electricity capacity to forty per cent of the total installed capacity in the same period.
- India is expanding its nuclear energy power plants and parks. According to NPCIL, India's fuel situation, with shortage of fossil fuels, is driving the nuclear investment for electricity, and 25% nuclear contribution is the ambition for the year 2050.

Fears about Nuclear Energy

1. **High Initial Capital Costs:** The initial setup of nuclear plants is too expensive as billion dollars are required to setup reactors and cost of building parts of power plant is also high.
2. **Radioactive Waste:** Radioactive waste is the waste product of nuclear plant fuel processing plants, research facilities and hospitals and is also produced when nuclear reactors and facilities are dismantled. There are numerous problems with the storage and disposal of nuclear waste.
3. **Scarceness of Nuclear Fuel:** The sources of nuclear fuel such as uranium reserves are limited and available in very few countries around the globe. Apart from this, large numbers of permissions are required from international authorities for processing of nuclear fuel and setting up of nuclear plants.
4. **Nuclear Weapons:** There are also apprehensions that the nuclear fuel used for generating nuclear power can also be used for preparing nuclear weapons which may have very dangerous effects.
5. **Radiation Accidents:** The radioactive waste produced during nuclear energy generation can be biggest threat to environment and human life. Some of the examples are Fukushima Daiichi nuclear power plant radioactive release in Japan and Chernobyl Nuclear disaster.

2019 MAIN ANSWERS

8. **What is India's plan to have its own space station and how will it benefit our space programme?** **(150 words, 10 marks)**

Ans: India is planning to launch its own space station by 2030, joining the league of the USA, Russia, and China to an elite space club. As of now, the International Space Station (ISS) is the only fully functioning space station and largest human-made body in low Earth orbit. The only countries that have had space stations so far are the USA, Russia, China and a consortium of nations that own the International Space Station (ISS). The proposed space station is envisaged to weigh 20 tonnes and serve as a facility where astronauts can stay for 15–20 days, and it would be placed in an orbit 400 km above earth.

Space Station

A space station is a habitable spacecraft capable of supporting human crewmembers and designed to remain in space. Space station is also called orbital station. It orbits around the Earth. Basically, it is a large spacecraft or man-made station in space, a home where astronauts live and also receives several spacecrafts from the Earth. It is a kind of science lab, many countries worked together to build it and also, work together to use it. The United States (US) and Russia have had orbiting space stations since 1971. The first space stations were the Russian Salyut program, the US Skylab program and the Russian Mir program.

Indian Space Station

The Indian space station will be much smaller (mass of 20 tonnes) than the International Space Station and will be used for carrying out microgravity experiments (not for space tourism). Preliminary plan for the space station is to accommodate astronauts for up to twenty days in space, and the project will be an extension of the Gaganyaan mission. It will orbit Earth at an altitude of around 400 km. ISRO (Indian Space Research Organisation) is working on space docking experiment (Spadex), a technology that is crucial for making the space station functional. Space docking is a technology that allows transferring humans from one spacecraft to another.

Significance

India is planning to have its own space station for undertaking separate missions to study the Sun and Venus, for strengthening its status as a leader in space technologies and further inspiring the young minds to take an interest in scientific fields. It is important to understand the impact of space technology on our lives in numerous fields such as communications, agriculture management, disaster management, land management and is essential for collecting meaningful scientific data, especially for biological experiments. It provides platforms for greater number and length of scientific studies than available on other space vehicles. Space stations are used to study the effects of long-term space flight on the human body. The space station will help to accelerate the development of reusable rockets, in-orbit docking systems, and manned missions and will create new opportunities for other spacecraft to dock as well as allowing for cross-collaboration experiments. The space station's laboratories allow crew members to do research that could not be done anywhere else. This scientific research benefits people on the Earth. Space research is even used in everyday life. The results are products called "spin-offs." Scientists also study what happens to the body when people live in microgravity for a long time.

9. **What is Cyberdome Project? Explain how it can be useful in controlling the Internet crimes in India.** **(150 words, 10 marks)**

Ans: Cyberdome project is a technological research and development centre of Kerala Police Department, conceived as a cyber-centre of excellence in cyber security, as well as technology augmentation for effective policing.

It envisages as a high tech, public-private partnership centre of collaboration for different stakeholders in the domain of cyber security and handling of cyber crimes in a proactive manner.

India has witnessed a 457% rise in cyber crime incidents under the Information Technology (IT) Act, 2000 from the year 2011 to 2016. Cyberdome project can be useful in controlling these Internet crimes in India. The project can help in preventing cyber crimes through development of a cyber threat resilient ecosystem in the country to defend against the growing threat of cyber attacks. To effectively tackle cybercrime, the government has collaborated with private sector and academia to conform rapidly changing technology world.

- The cyberdome will act as an online police patrol. Through its Anti-Cyber Terror Cell and a cybersecurity training unit, its officers will generate intelligence on various cyber threats in near real-time and track fugitives online by monitoring their online activities, including social networking sites.
    - It will create a digital repository of stolen and lost vehicles and travel documents, track online payments to prevent money laundering and channelling of funds to dubious organisations and issue cyber security advisories.
    - Cyberdome will have centres for social media awareness, protection of children on the Internet, Internet monitoring and ICT (Information and Communication Technology) in service delivery.
    - Cyberdome in collaboration with the RBI, Banks, payment gateways and other wallet groups can tackle financial fraud.
    - Through its ransomware school, Cyberdome can understand, analyse and mitigate ransomware infections, create standard operating procedures to deal with ransomware, creating awareness among the public as well as government departments about ransomware and its precautionary steps.
    - The cyberdome is expected to enable sleuths to obtain vital leads in cases of cyber-related offences using advancements in the field of information technology.
    - Of late, cyberdome has used social engineering as the lynchpin of its policing strategy to snoop on radical groups that use the Internet for extremist activities.
    - Cyberdome has made successful propaganda war against online games such as Blue Whale.

10. **How is the Government of India protecting traditional knowledge of medicine from patenting by pharmaceutical companies?**

(250 words, 15 marks)

Ans: Traditional medicine comprises medical aspects of Traditional Knowledge (TKs) that developed over generations within various societies before the era of modern medicine. India has a diverse set of traditional practices arising out of Ayurveda, Siddha, and diverse tribal practices that have developed over generations.

Issues Involved in the Protection of Traditional Knowledge

- **Non-codification of TKs:** Non-codified traditional knowledge is vulnerable to lose its relevance with the influence of modern medical practices.
- **Patenting of TKs by biotechnology companies:** Various cases of bio-piracy were raised in India where Biotech companies used the Traditional Knowledge to develop products and issued patents. For example, Jeevani sports drug was derived from traditional knowledge of Kani tribe.
- **Access and Benefit Sharing from TKs:** Traditional knowledge is also often held collectively by communities, rather than by individual owners. This makes the benefit sharing difficult.
- **Inadequate International Regimes for protection of TKs:** Due to the community nature of traditional knowledge, it is not recognised in international laws explicitly.

Steps of Government to Protect TKs

Legal Steps

- **Biological Diversity Act:** It contains the provision for fair and equitable sharing of the benefits arising out of the utilisation of genetic resources.
- **Forest Rights Act 2006:** It provides for community rights over forest resources. It can help in the protection of traditionally owned knowledge and practices. It also protects and promotes the livelihood of tribal community which is often based on their knowledge system and forest produce.
- **The Geographical Indication of Goods (Registration and Protection) Act, 1999:** It provides a collective right to the holders of the traditional knowledge associated with a particular geographical area.

Institutional Steps

- **AYUSH Ministry:** To cultivate education and research in Ayurveda, Yoga, Naturopathy, Unani, Siddha, Homoeopathy, Sowa-Rigpa (Traditional Tibetan medicine), and other indigenous medicine systems.

Policy Measures, Initiatives and Projects

- **Traditional Knowledge Digital Library (TKDL):** It is a repository of traditional knowledge, especially of medicinal plants and formulations used in Indian system of medicine.
- **National Ayush Mission:** It promotes AYUSH medical practices, quality enhancement and mainstreaming these practices to our healthcare system. It also promotes the education and awareness of AYUSH medicine system.
- **Research Centres and National Institutes** have been created across India in the fields of Ayurveda, Unani, Homoeopathy, Siddha.
- **India has also signed agreements** with the United Kingdom Intellectual Property Office and other countries' patent offices like the USA etc., to prevent the grant of invalid patents by giving patent examiners at International Patent Offices access to the TKDL database for patent search and examination.

The interest in traditional medicines is growing rapidly due to the increased side effects, adverse drug reactions, and cost factor of modern medicines. So, awareness and development of various traditional knowledge practices should be done along with a focus on their mainstreaming so as to reap its potential of great livelihood support particularly for the tribals. Also, a sui-generis system should be developed that can recognise the diverse nature of traditional knowledge and provide them with adequate legal and commercial protection.

11. How can biotechnology improve the living standards of farmers? (250 words, 15 marks)

Ans: In India, the majority of the population is involved in agriculture but it is not remunerative enough, especially in areas which did not go through the stages of the green revolution. In this scenario, biotechnology holds good potential to transform agriculture. It can affect all steps of the production chain, from agrochemical inputs to final food processing.

- Under **biotechnology**, plants, bacteria, fungi and animals whose genes have been altered by manipulation **(Recombinant DNA Technology)** are called **Genetically Modified Organisms (GMO)**. GMO technology has brought **significant changes in agriculture** and areas related to it.
- **Tissue Culture** is the science of cultivating animal/ plant tissue in a prepared medium. Technologies based on this can be harnessed to achieve crop improvement objectives.
- Crops have been made **more tolerant to abiotic stresses** (cold, drought, salt, heat) so the farmers do not have to worry about the weather conditions and can help plants adapt to environmental stress and climate change.
- It has **reduced reliance on chemical pesticides (pest-resistant crops)** which is pocket-friendly for the farmers and eco-friendly for the consumer by eliminating harmful chemicals from the ecosystem.
- **Post-harvest losses have been reduced** by increasing crops' abilities to withstand the transportation period without being perished.
- **Efficiency of mineral usage by plants has been increased** by it (this prevents early exhaustion of fertility of soil), so a piece of land can be used for a long time for equally good yields.
- It has **enhanced the nutritional value of food** (like Vitamin A enriched rice) which increases the market value of the product, profiting the farmers and improving human health.
- Plants developed using biotechnology **naturally resist specific insects, weed plants and diseases** so there is no loss of crop due to these reasons. (Like **Bt crops**).
- In addition, it has been **used to create tailor-made plants** to supply alternative resources to industries, in the form of starches, fuels and pharmaceuticals, etc., which can boost the agricultural-industrial relations uplifting the farmers.

The benefits of biotechnology are especially meaningful at a time when our global population is growing and our demand for food is increasing, mainly in developing countries. Biotechnology allows farmers to grow more food on less land using environmentally sustainable farming practices which are necessary for them to have a good income and a better living standard. Biotechnology is a powerful tool to feed an increasing world population, but its "positive and negative potential" should be carefully evaluated.

2020 MAIN ANSWERS

12. What do you understand by nanotechnology and how it is helping in health sector?

Ans: Nanotechnology is the understanding and control of matter at the nanoscale where unique phenomena enable novel applications. The applications of nanotechnology widely range from industrial, medicinal to energy uses.

1. Cancer detection and treatment: gold nanoparticles as probes for the detection of targeted sequences of nucleic acids
2. Drug delivery: deliver medication directly to cancer cells
3. Imaging and diagnostic tools: paving the way for earlier diagnosis, more individualized treatment options, and better therapeutic success rates
4. Diagnosis and treatment
5. Genetics: development of novel gene sequencing technologies
6. Regenerative medicine
7. Vaccine development
8. Smart pills: pharmaceutical pills but perform more advanced functions such as sensing, imaging, and drug delivery
9. Nanobots: micro-scale robots, which essentially serve as miniature surgeons
10. Nanofibres: Nanofibers are being used in wound dressings and surgical textiles

However, toxicity, lack of proper knowledge about the effect of nanoparticles on biochemical pathways and expensive processes and treatments make them less desirable.

13. How is science interwoven deeply with our lives? What are the striking changes in agriculture triggered off by the science-based technologies?

Ans: Many believe that science is the greatest collective endeavour. From the micro to the macro level, science, and technology influence almost every aspect of human life. The role of science-based technologies in transforming agriculture is one such example.

Impact of Science-Based Technologies on Agriculture

- Green Revolution: India achieved self-sufficiency in food grain production.
- GM Crops: Genetically Modified (GM) crops increased productivity and food security.
- Precision Agriculture: Information and communication technologies and mobile technology is playing an important role in monitoring and controlling crop irrigation systems.
- Sustainable Agriculture: Commercialisation of agriculture all across the world has led to the increasing use of chemical fertilisers, widespread mechanisation, etc. This has led to environmental detrimental agriculture.
- The ongoing researches in agriculture sciences can make agriculture more sustainable.

Whether science and technology is a boon or bane, is the never-ending topic of debate. It is difficult to predict the future of technology in agriculture but there are many promising trends and pilot projects.

14. Discuss different types of cybercrimes and measures required to be taken to fight the menace?

Ans: Cybercrimes are criminal activities performed on internet platform or using internet-based services. They are considered one of the emerging threats that have impacted peace and tranquillity in the society.

Different types of Cybercrimes

- Bullying and blackmail – Using internet and social media to influence actions of younger members or vulnerable sections.

  For example: Blue Whale challenge
- Fake news – They can be communal as well as on sensitive issues.

  For example: Child kidnapping fake news
- Financial fraud – Targets people using digital modes and scams them of their savings.

For example: Lottery email

- Terrorist recruitment

For example: ISIS recruitment using the internet

Measures to fight menace

- Digital literacy
- Parental monitoring
- Authority monitoring – Contents that are dangerous to society such as communal posts, terrorist groups, fake news, etc. should be removed by an authority set up for the particular purpose.

Thus, cyber crimes have to be taken seriously because as internet becomes more accessible, more such potential threats can emerge.

15. COVID-19 pandemic has caused unprecedented devastation worldwide. However, technological advancements are being availed to win over the crisis. Give an account of how technology was sought to aid management of the pandemic?

Ans: Covid-19 pandemic is a far greater social, economic and political phenomenon than merely a biomedical one. Due to its ability to spread rapidly and its ill effects on lives and livelihoods, the pandemic turned into one of the worst humanitarian crises in the recent history.

Technological aid management of the pandemic

- The Access to Covid-19 Tools (ACT) Accelerator is a pioneering international teamwork to fast-track development, production and equitable access to Covid-19 tests, treatments and vaccines.
- "Arogya Setu" app – developed to track Covid-19 patients
- PM Innovate Challenge – inviting applications from individuals, start-ups and companies to provide innovate technological solutions to fight the virus.
- Co-WIN or the Covid-19 Vaccine Intelligence Network – is an extension of electronic Vaccine Intelligence Network (eVIN) – digitised tech platform for effectively rolling out and scaling up the COVID Vaccine Distribution System.
- Tata CRISPR – world's first diagnostic test to bring into effective action a specially adapted Cas9 protein to successfully identify the virus causing Covid-19.
- CAWACH (Centre for Augmenting WAR with COVID-19 Health Crisis – supports potential start-ups targeting innovations to control Covid-19.
- AI-enabled MyGov Corona Helpdesk – improved outreach and engagement.
- RT–PCR Test
- Rapid Antibody Detection Tests
- Indigenous ventilators developed – PRANA-VAYU, Ruhdaar
- COVID-19 National Teleconsultation Centre (CoNTeC)
- CPCB's biomedical waste tracking mobile application called COVID19BWM
- PM eVIDYA – online education platforms

Besides implementable technologies related to searching of potential metabolite biomarker signature for COVID infection, developing antiviral surface coatings to prevent the spread of infections and development of antibody-based capturing of COVID-19 were other sought-after initiatives.

16. Describe the benefits of deriving electric energy from sunlight in contrast to the conventional energy generation. What are the initiatives offered by our government for this purpose?

Ans:

- Solar Energy is available throughout the day which is the peak load demand time.
- Its conversion equipment have longer life and need lesser maintenance and hence provide higher energy infrastructure security.
- Low running costs and grid tie-up capital returns **(Net Metering)**.
- Unlike conventional thermal power generation from coal, they do not cause pollution and generate clean power.
- No overhead wires - no transmission loss

Government initiatives

- **Ministry of new and renewable energy** – nodal agency to tackle India's renewable energy issues.
- **National Solar Mission** – initiative to promote ecologically sustainable growth
- **The Indian Renewable Energy Development Agency (IREDA)** is a Non-Banking Financial Institution – for providing term loans for renewable energy and energy efficiency projects.
- **National institute of solar energy** is created as autonomous institution under MoNRE is the apex body for R&D.

- Establishment of **solar parks and ultra major solar power project** and enhancing grid connectivity infrastructure.
- Promotion of **canal bank and canal tank solar infrastructure.**
- Sustainable rooftop implementation of **Solar Transfiguration of India (SRISTI)** scheme to promote rooftop solar power projects in India.
- **Suryamitra** programme to prepare qualified workforce.
- **Renewable purchase obligation** for large energy consumer customers.
- National green energy programme and **green energy corridor.**

Way forward

- Strong financial measures are required to finance the solar projects, innovative steps like **green bonds, institutional loans and clean energy fund** can play a crucial role.
- Promotion of research and development in renewable energy sector, especially in storage technology.
- Proper mechanism should be provided to tackle China's dumping of solar equipments.
- Framework to avoid unnecessary delays in policy decision making and implementation.
- India needs **Solar Waste Management and Manufacturing Standards Policy.**

2021 MAIN ANSWERS

17. How is S-400 defence system technically superior to any other system presently available in the world?

Ans: The S-400 (Triumf) is a mobile long range surface-to-air missile (LR-SAM) system developed by Russia. It is considered as one of the world's most advanced air defence systems as it can simultaneously track and neutralize a range of incoming aerial threats.

India has engaged with Russia for the purchase of five S-400, missile defence system.

S-400 are superior to other missile defence systems available in the world as:

1. It comes with a multifunction radar, autonomous detection and targeting system, anti-aircraft missile systems and a command-and-control centre.
2. Engages target - long range of 400 km at 27 km altitude.
3. S-400 can be deployed in 5 minutes, as compared to 25 minutes taken by Patriot.
4. The highest speed of S-400 at 4.8 km/s. surpasses Patriot's 1.38 km/s.
5. It has an edge over the US-made THAAD, in terms of range and hitting targets beyond the horizon.

With India facing two inimical neighbours in its western and eastern borders, a possibility of two-front engagement cannot be denied. In this light even though, purchase of S-400 runs the risk of attracting US sanctions under CAATSA, it is indispensable for India's strategic/tactical needs.

18. What are the research and developmental achievements in applied biotechnology? How will these achievements help to uplift the poorer sections of the society?

Ans: Biotechnology is a branch of science that generates cellular and biomolecular processes to develop technologies and products that help improve our lives and health of our planet. Biotechnology is helping to heal the world by harnessing nature's own toolbox and using our own genetic makeup.

Research and developmental achievements

- **Stem Cell Research:** Stem cells have the ability to keep on dividing infinitely and have the capacity to distinguish into different types of body cells during the early development of an organism.
- **Human Genome Project:** Determining the sequence of nucleotide base pairs that make up human DNA.
- **Targeted Cancer Therapies:** reduce damage to healthy cells.
- **CRISPR:** Clustered Regularly Interspersed Short Palindromic Repeats (CRISPR), a ground breaking tool in medical research. HIV research is one of its many uses.

Role in uplifting poorer sections of society

- Biotechnology is assisting to expand the income of marginal farmers by increasing crop yield and making it climate and pest resilient.
- It has revolutionised the medical science leading to controlled death rate and world class treatment possible in India itself.
- By genome sequencing, biotechnology helps in accessing health of the people from the corners of India which ultimately proves conducive for the government in framing targeted policy initiatives.
- It also proves beneficial in expanding the shelf life of food products, which in turn, keeps their price in check for the poor.
- Pollution attacks poor the most. Biotechnology helps in reducing pollution and, thus, alleviates their suffering. For example, landfills are cleaned through bioremediation techniques.

19. The Nobel Prize in Physics of 2014 was jointly awarded to Akasaki, Amano and Nakamura for the invention of Blue LEDs in 1990s. How has this invention impacted the everyday life of human beings?

Ans: LEDs are basically semiconductors that have been built so they emit light when they are activated. White light, which we generally use, is made by a combination of red, green and blue light. Scientists say that while it was easier to make red and green LEDs, making Blue LED was the ultimate challenge.

Impact of this invention on our everyday life

- **Electricity Conservation:** A modern white LED light bulb converts more than 50% of the electricity it uses into light. This is opposed to the 4% conversion rate for incandescent bulbs.
- **Increasing Access to Electricity:** White LEDs' efficiency makes them appealing for getting lighting to folks living in regions without electricity supply. A solar installation can charge an LED lamp to last for a long time.
- **Smart Energy Efficient Homes:** a requirement for any smart home.
- **Enables Other Technological Advancements:** The LEDs are more energy-efficient than the fluorescent lights that are sometimes used for backlighting, and allow for very thin displays.
- **Increased Ability to Store Data:** Blu-ray players, use blue LED lasers to read data off a digital optical disc. It has become possible to store five to 10 times as much data.

Researchers are exploring other applications of LEDs as well, like in transmitting data from the Internet and water purification. These advancements show that LEDs will continue to impact everyday life of humans for years to come.

2022 MAIN ANSWERS

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PART

D

LIST OF SCIENTIFIC INSTRUMENTS
LIST OF IMPORTANT INVENTIONS AND INVENTORS
LIST OF IMPORTANT SCIENTIFIC DAYS/EVENTS
LIST OF IMPORTANT RESEARCH INSTITUTES IN INDIA

LIST OF SCIENTIFIC INSTRUMENTS

S. No.	Scientific Instrument Name	Inventor Name	Uses
1.	Altimeter	Paul Kollsman	An instrument used for measuring altitude of an object above the sea level (mainly used in aircrafts)
2.	Anemometer	Leon Battista Alberti	Used for measuring pressure, speed and direction of the wind
3.	Ammeter	Friedrich Drexler	It is used for measuring electric current
4.	Audiometer	Alexander Graham Bell	Used for measuring the intensity of sound
5.	Accelerometer	George Atwood	Used for measuring acceleration
6.	Barometer	Evangelista Torricelli	Used for measuring atmospheric pressure and conditions
7.	Bolometer	Samuel Pierpont Langley	It is used for measuring infra-red (heat) Radiation
8.	Calorimeter	Antoine Lavoisier	Used for measuring quantity of heat
9.	Cardiogram	Willem Einthoven	Traces movement of the heart (recorded on a cardiograph)
9.	Commutator	William Sturgeon	It is used in generators to reverse the direction of electric current
10	Cyclotron	Ernest Lawrence	It is used in microwave oscillator of accelerating charged particles
11.	Chronometer	John Harrison	Used to determine longitude by means of celestial navigation
12.	Dilatometer	Abbe and Fizeau	Measures changes in volume of substances
13.	Electrometer	William Snow Harris	Used for measuring potential difference in electrical current
14.	Endoscope	Philipp Bozzini	Used to examine internal part of the body
15.	Fathometer	Reginald Fessenden	It is used for measuring depth of the ocean
16.	Galvanometer	William Thomson	It is used to measure electric current
17.	Hydrometer	Antoine Baume	Measures the relative density of liquid
18.	Hygrometer	Leonardo Da Vinci	Measures the humidity of air or any gas
19.	Lactometer	Dicas	It is used to measure the relative density of milk
20.	Micrometer	William Gascoigne	Converts sound wave into electrical vibration
21.	Microscope	Zacharias Janssen	Used to obtain magnified view of small objects
22.	Nephelometer	Theodore W. Richards	It measures the scattering of light by particles suspended in a liquid
23.	Odometer	Benjamin Franklin	Used for measuring distance travelled

S. No.	Scientific Instrument Name	Inventor Name	Uses
24.	Ohmmeter	William Thomson/Lord Kelvin	Measures electrical resistance of vehicles
25.	Ondometer	Zhang Heng	Measures the frequency of electromagnetic wave
26.	Optometer	W. Porterfield	Used for testing the refractive power of the eye
27.	Periscope	Hippolyte Marié-Davy	Used to view objects above sea level
28.	Phonograph	Thomas Edison	Used for reproducing sound
29.	Photometer	Dmitry Lachinov	Measures light intensity or optical properties of solutions or surfaces
30.	Polygraph	John Augustus Larson	Measures and records several physiological indices such as cblood pressure, pulse, respiration, and skin conductivity (used as lie detector)
31.	Pyrheliometer	K. Angstrom	It is used for measuring solar radiation
32.	Pyrometer	Pieter van Musschenbroek	It is used for measuring very high temperature
33.	Quadrant	Hadley	Measures altitudes and angles in navigation and astronomy
34.	Radar	Heinrich Hertz	Radio, detection and ranging
35.	Rain Gauge	During the reign of King Sejong, the Great of the Joseon Dynasty in Korea	Instrument used to measure the amount of liquid precipitation over a set period of time
36.	Refractometer	Ernst Abbe	Measures a refractive index of a substance.
37.	Sextant	John Hadley and Thomas Godfrey	Used to measure the angle between any two visible objects
38.	Seismometer	Zhang Heng	Measures motion of the ground, including those of seismic waves generated by earthquakes, volcanic eruptions, and other seismic sources
39.	Spectroscope	Robert Wilhelm Bunsen and Gustav Robert Kirchhoff	Used for spectrum analysis
40.	Speedometer	Croatian Josip Belušic‘	Used for measuring speed of the vehicle
41.	Spherometer	Robert-Aglaé Cauchoix	Measures curvature of spherical objects
42.	Sphygmomanometer	Samuel Karl Ritter von Basch	Used to measure blood pressure
43.	Stethoscope	René Laennec	Used for hearing and analysing the sound of heart
44.	Tachometer	Dietrich Uhlhorn	Used for measuring the speed of machines
45.	Telemeter	James Watt	Used for measuring distances to remote objects
46.	Telescope	Hans Lippershey	Used for magnified view of distant objects
47	Thermometer	Santorio	Used for measuring temperature
48.	Thermostat	Albert Butz	Used for regulating temperature
49.	Transformer	Ottó Bláthy	Used for converting high voltage to low and low voltage to high, without converting its frequency.
50.	Viscometer	Austin Norcross	Measures viscosity of liquid
51.	Voltmeter	Andrew Kay	Used for measuring electric potential difference two points
52.	Wattmeter	Ottó Bláthy	Used for measuring electric power

LIST OF IMPORTANT INVENTIONS AND INVENTORS

S. No.	Inventions	Inventors	Country
1.	Aircraft	Wright Brothers	U.S.A.
2	Automatic Calculator	Wilhelm Schickard	Germany
3.	Animation	Emile Reynaud	France
4.	Aspirin	Dr. Felix Hoffman	Germany
5.	Atom Bomb	Julius Robert Oppenheimer	U.S.A.
6.	Barometer	Evangelista Torricelli	Italy
7.	Ballpoint Pen	Laszlo Biro	France
8.	Bifocal Lens	Benjamin Franklin	U.S.A.
9.	Cement	Joseph Aspdin	England
10.	Cinema	Lumière Brothers	France
11.	Computer	Charles Babbage	U.K.
12.	Diesel Engine	Rudolf Diesel	Germany
13.	Dynamite	Alfred B. Nobel	Sweden
14.	Electric Battery	Volta	Italy
15.	Electric Generator	Michael Faraday	England
16.	Electric Lamp	Thomas Alva Edison	U.S.A.
17.	Elevator	Elisha G. Otis	U.S.A.
18.	Fountain Pen	Lewis Edson Waterman	U.S.A.
19.	Gramophone	Thomas Edison	U.S.A.
20.	Helicopter	Igor Sikorsky	Russia
21.	Light Bulb	Heinrich Goebel	Germany
22	Microwave Oven	Percy Spencer	U.S.A.
23.	Machine Gun	Richard Gaffing	U.S.A.
24.	Motor Scooter	Greville Bradshaw	England
25.	Microscope	Zacharis Janssen	Netherlands
26.	Pacemaker	Dr. Paul Zoll	U.S.A.
27.	Penicillin	Alexander Fleming	U.K.
28.	Radio	Guglielmo Marconi	Italy
29.	Revolver	Samuel colt	U.S.A.
30.	Small Pox Vaccine	Edward Jenner	England
31.	Steam Engine	James Watt	U.K.
32.	Submarine	David Bushnell	U.S.A.
33.	Telegraph	Samuel Morse	U.S.A.
34.	Telephone	Alexander Graham Bell	Canada
35.	Television	John Logie Baird	England
36.	Vaccination	Dr. Edward Jenner	England
37.	World Wide Web	Tim Berners Lee	U.K.
35.	X-Ray	Wilhelm Conrad Roentgen	Germany

LIST OF IMPORTANT SCIENTIFIC DAYS/EVENTS

S. No.	Date	Scientific Day/Event
1.	First week of January	Indian Science Congress
2.	January 30	National Anti Leprosy Day
3.	February 28	National Science Day
4.	March 16	Measles Vaccination Day
5.	March 24	TB Day
6.	March 23	World Meteorological Day
7.	April 7	World Health Day
8.	April 22	Earth Day
9.	May 1–7	Malaria Prevention Week
10.	May 11	Technology Day
11.	May 17	World Telecommunication Day
12.	June 5	World Environment Day
13.	July 11	World Population Day
14.	August 1–7	World Breast–Feeding Day
15.	August 25–September 8	National Eye Donation Fortnight
16.	September 1–7	National Nutrition Week
17.	September 8	International Literacy Day
18.	September 8	Eye Donation Day
19.	September 16	World Ozone Day
20.	October 1–7	Wildlife Week
21.	October 1st Monday	World Habitat Day
22.	October 2nd Wednesday	International Day for Natural Disaster Reduction
23.	October 9	World Post Day
24.	October 16	World Food Day
25.	October 24	United Nations Day
26.	October 24	World Development Information Day
27.	November 10	International Science Day
28.	November 19–December 18	National Environment Month
29.	December 1	World AIDS Day
30.	December 2	World Computer Literacy Day
31.	December 2	National Pollution Prevention Day
32.	December 14	National Energy Conservation Day
33.	December 29	International Day For Biological Diversity
34	December 27–31	National Children's Science Congress

LIST OF IMPORTANT RESEARCH INSTITUTES IN INDIA

S. No.	Institution Name	Place
1.	All India Institute of Speech and Hearing	Mysore
2.	All Indian Malaria Research Institute	New Delhi
3.	Aryabhatta Research Institute of Observational Sciences	Nainital
4.	Birbal Sahni Institute of Palaeobotany	Lucknow
5.	Central Building Research Institute	Roorkee
6.	Cattle Breeding Institute	Hisar
7.	Central Coconut Research Institute	Kerala
8.	Central Drug Research Institute	Lucknow
9.	Central Tobacco Research Institute	Rajahmundry
10.	Central Electronics Engineering Research Institute	Pilani
11.	Central Food Technological Research Institute	Mysore
12.	Central Jute Technological Research Institute	Kolkata
13.	Central Potato Research Institute	Shimla
14.	Central Rice Research Institute	Cuttack
15.	Central Glass and Ceramic Research Institute	Kolkata
16.	Central Institute for Cotton Research	Nagpur
17.	Central Institute for Agricultural Engineering	Bhopal
18.	Central Institute of Brackish Water Aquaculture	Chennai
19.	Central Institute of Education Technology	New Delhi
20.	Central Institute of Fisheries Education	Mumbai
21.	Central Institute of Fisheries, Nautical and Engineering Training	Cochin
22.	Central Institute of Fresh Water Aquaculture	Bhubaneswar
23.	Central Institute of Plastic Engineering and Technology	Hajipur
24.	Central Institute of Psychiatry	Ranchi
25.	Central Leather Research Institute	Adyar (Chennai)
26.	Central Mine planning and Design Institute Limited	Ranchi
27.	Central Research Institute for Dryland Agriculture	Hyderabad
28.	Central Sheep and Wool Research Institute	Avikanagar
29.	Central Leprosy Training and Research Institute	Chingelpet
30.	Central Sugarcane Research Institute	Coimbatore
31.	Central Electrochemical Research Institute	Karaikudi
32.	Central Scientific Instrument Organization	Chandigarh
33.	Centre for Excellence in Basic Sciences	Mumbai
34.	Directorate of Forest Education	Dehradun
35.	Film and Television Institute of India	Pune
36.	Fluid Control Research Institute	Kanjikode
37.	Indian Agricultural Research Institute	New Delhi
38.	Indian Association for the Cultivation of Sciences	Kolkata
39.	Indian Diamond Institute	Surat
40.	Indian Institute of Architects	Mumbai
41.	Indian Institute of Astrophysics	Bangalore
42.	Indian Institute of Chemical Biology	Kolkata
43.	Indian Institute of Chemical Technology	Hyderabad
44.	Indian Institute of Ecology and Environment	New Delhi
45.	Indian Institute of Forest Management	Bhopal
46.	Indian Institute of Petroleum	Dehradun
47.	Indian Institute of Petroleum and Energy	Visakhapatnam
48.	Indian Institute of Plantation Management	Bangalore
49.	Indian Institute of Pulses Research	Kanpur
50.	Indian Institute of Remote Sensing	Dehradun
51.	Indian Institute of Science	Bangalore
52.	Indian Institute of Social Welfare and Business Management	Kolkata
53.	Indian Institute of Soil Sciences	Bhopal
54.	Indian Institute of Space Science and Technology	Trivandrum
55.	Indian Institute of Spices Research	Calicut
56.	Indian Institute of Tropical Metrology	Pune
57.	Indian Institute of Natural Resins and Gums	Ranchi
58.	Indian National Centre of Ocean Information Services	Hyderabad

S. No.	Institution Name	Place
59.	Indian School of Mines	Dhandbad
60.	Indian Veterinary Research Institute	Bareilly
61.	Indira Gandhi Centre for Atomic Research	Kalpakkam
62.	Industrial Toxicology Research Institute	Lucknow
63.	Institute for Plasma Research	Gandhinagar
64.	Institute for Studies in Industrial Development	New Delhi
65.	Institute of Food Security	Gurgaon
66.	Institute of Mathematical Sciences	Chennai
67.	Institute of Physics	Bhubaneswar
68.	International Institute for Population Sciences	Mumbai
69.	Jawaharlal Nehru Centre for Advanced Scientific Research	Bangalore
70.	Morarji Desai National Institute of Yoga	New Delhi
71.	National Academy of Agricultural Sciences	New Delhi
72.	National Botanical Research Institute	Lucknow
73.	National Brain Research Centre	Manesar
74.	National Civil Defence College	Nagpur
75.	National Dairy Research Institute	Karnal
76.	National Environmental Engineering Research Institute	Nagpur
77.	National Institute of Agricultural Marketing	Jaipur
78.	National Institute of Criminology and Forensic Science	New Delhi
79.	National Institute of Homeopathy	Kolkata
80.	National Institute of Hydrology	Belgaum, Roorkee
81.	National Institute of Industrial Engineering	Mumbai
82.	National Institute of Mental Health and Neurosciences	Bangalore
83.	National Institute of Ocean Technology	Chennai, Nellore
84.	National Institute of Science Education and Research	Bhubaneswar
85.	National Power Training Institute	Faridabad
86.	National Sugar Research Institute	Kanpur
87.	National Tuberculosis Institute	Bangalore
88.	National Geophysics Research Institute	Hyderabad
89.	Physical Research Laboratory	Ahmedabad
90.	Raman Research Institute	Bangalore
91.	Rajiv Gandhi Institute of Petroleum Technology	Rae Bareli
92.	Raman Research Centre	Bengaluru
93.	Saha Institute of Nuclear Physics	Kolkata
94.	Tata Institute of Fundamental Research	Mumbai, Hyderabad
95.	Variable Energy Cyclotron Centre	Kolkata